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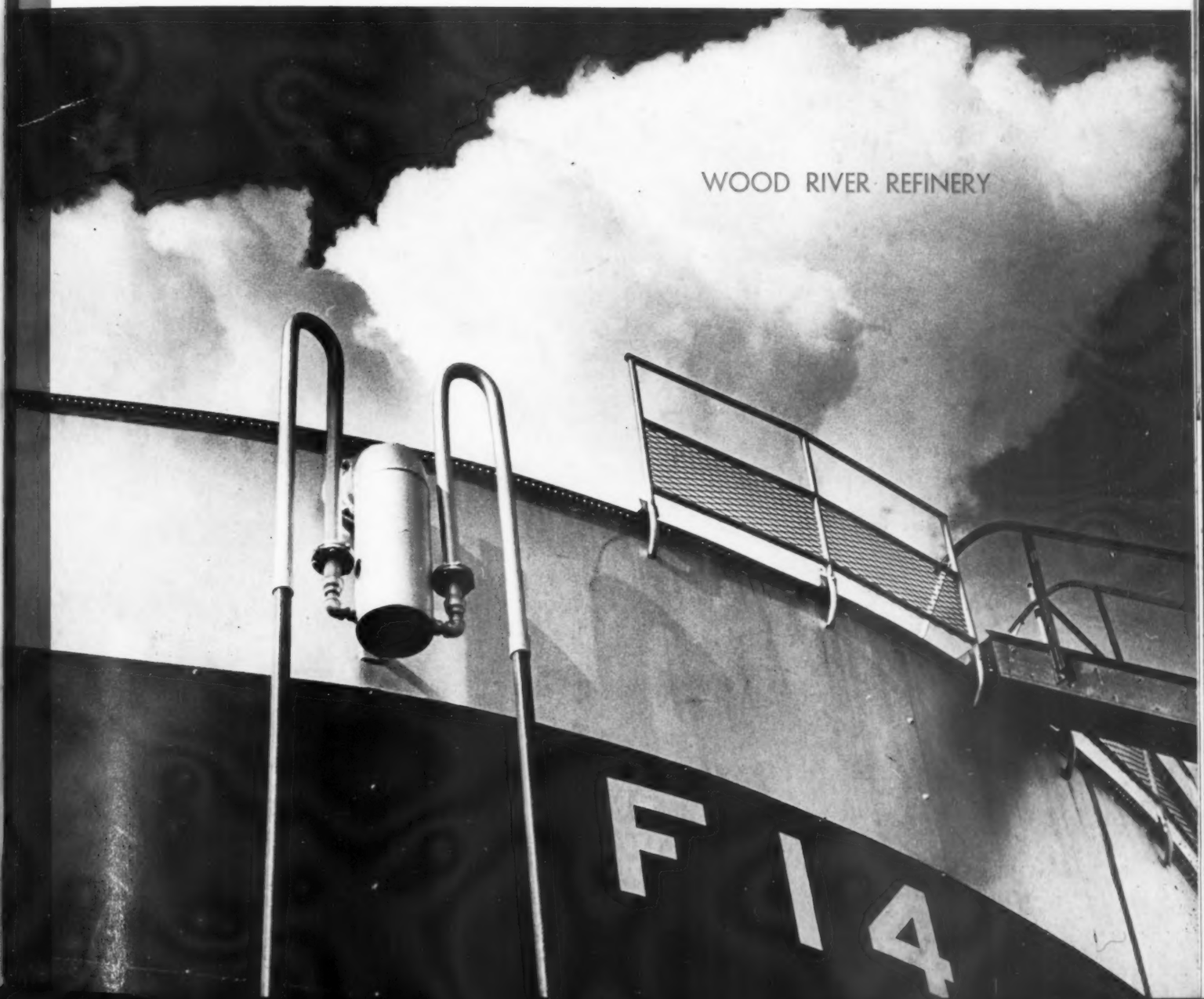

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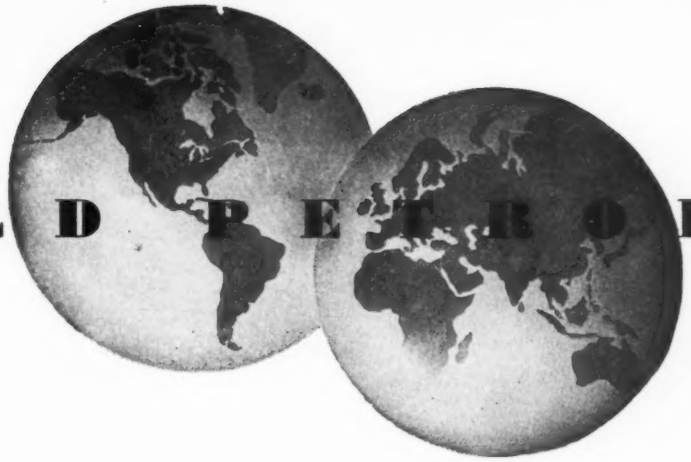

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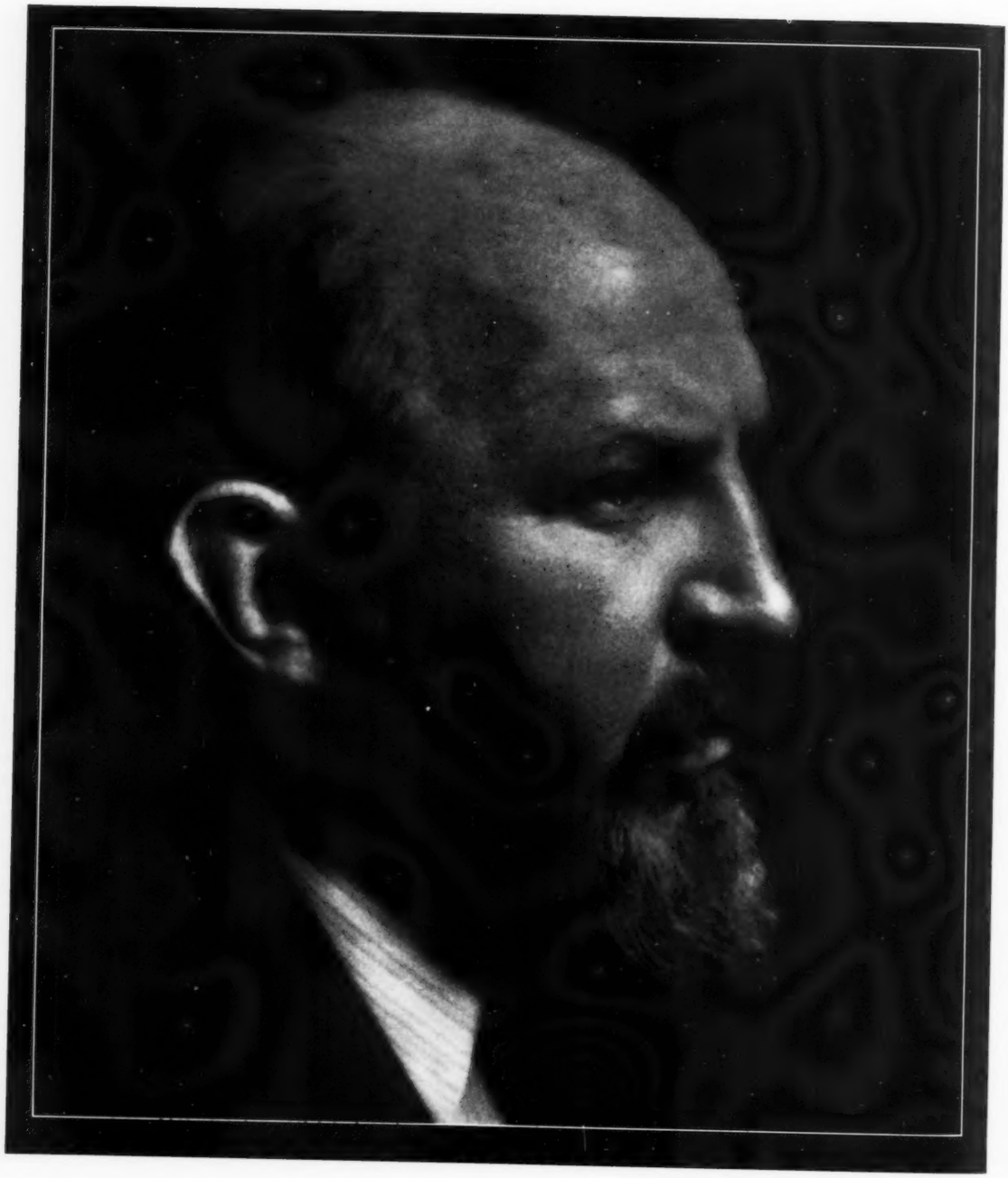


RUSSELL PALMER

EDITORIAL

RUSSELL PALMER

RUSSELL PALMER, founder of World Petroleum and publisher of affiliated magazines in Los Angeles, London and Toronto, Canada, died suddenly Thursday, August 8, at La Jolla, California. Though cut down in the prime of life in his fiftieth year, Mr. Palmer not only left the impress of a strong personality on the publications with which he was directly associated but influenced the whole course of industrial journalism in the direction of greater editorial strength and independence and particularly toward higher standards of typographic and artistic excellence.

Because he was interested in all aspects of life and human relations it was natural that Russell Palmer should have started his career as a newspaper reporter. After a boyhood spent in western Pennsylvania and a year at Dartmouth College he struck westward to Seattle, Washington, in search of his first job, being influenced in his choice of a location by the fact that Seattle was the most distant point to which he could go without leaving the United States.

In the course of his reportorial job of covering the Seattle waterfront, Mr. Palmer met Mr. Miller Freeman, publisher of the *Pacific Fisherman* and other Pacific coast trade papers. So impressed was Mr. Freeman with the ability and enterprise of the young reporter that he offered him a position with his group of publications. Within a few years Mr. Palmer's contribution to the growth of these journals had assumed such importance that the corporation became the Freeman-Palmer Company.

In 1914 Mr. Palmer came to New York as the Eastern representative of the Freeman-Palmer Company and in the ensuing ten years he built up a group of industrial magazines of his own including *Motorship, Diesel Power, Canning Age* and *Fishing Gazette*. On the organization of National Trade Journals Inc. in 1928, these four journals were purchased for inclusion in the combination, leaving Mr. Palmer with a competence but without the occupation that his active mind required.

During the years spent in the field of trade journalism, Mr. Palmer had gradually formed a conception of a new type of industrial magazine—a journal that should be as carefully edited and as attractive in form as the best publications in the general field and that should be able to take a place of constructive leadership in the industry it represented. These ideals took shape in 1930 in World Petroleum which immediately drew widespread attention in the publishing trade by its treatment of subject matter and the attractiveness of its dress.

Meanwhile Mr. Palmer's interest in petroleum had led to his acquisition of *Petroleum World* and *Oil Age* and their consolidation under the title of the former into the leading oil magazine of the Pacific Coast. In 1935 he obtained control of *Petroleum Times*, the oldest and most important journal of the British oil industry, and in 1940 he became the sponsor of *Canadian Oil and Gas*, devoted to the growing Canadian industry. He also established *World Petroleum Directory*, now issued annually as the *Petroleum Register*. Other members of the group are *Facts About Sugar*, the Spanish magazine *El Mundo Azucarero*, and various reference books and directories relating to the sugar industry.

An ardent traveler, Mr. Palmer spent much of his time in Europe during the past ten years. He was particularly fond of Spain and his admiration for the historic treasures of Spanish art, architecture and literature caused him to become an active supporter of General Franco's revolt against communist domination of the country. As a purely voluntary service he went through two campaigns preparing a photographic record of the war which he subsequently presented to the Spanish nation. He also wrote many articles and delivered addresses before American audiences in an effort to promote a better understanding of the fundamental factors involved in the struggle between communism and western civilization.

To his business associates, Mr. Palmer was a constant inspiration. His quick perception, broad knowledge and unerring instinct in dealing with business and editorial problems, and his generous appraisal of the efforts of others, commanded both the respect and the unswerving loyalty of the members of his organization. His keen interest in many and diverse subjects and the enthusiasm he gave to causes that appealed to him attracted a wide circle of devoted friends in many walks of life and on both sides of the Atlantic.

To those who were privileged to work in close collaboration with Russell Palmer his memory remains as one who loved life, lived it vigorously and strove mightily for all that he believed in.

POLITICAL INTERFERENCE WITH DEFENSE CAMPAIGN

BEHIND the project for adequate national defense stands a united American people. When the President put before the country the need for vast expenditure and tremendous effort to strengthen the armed power of the nation his words met an instant response. Members of Congress regardless of party have voted one huge appropriation after another with practical unanimity. Business men called to Washington to aid in the work of organizing the resources and industries of the country responded promptly and are working unceasingly to put in motion the machinery of production needed for the greatest national task ever undertaken.

At the very beginning of this movement the statement was officially promulgated that in the great effort of assuring the nation's protection politics should play no part. In this spirit the people of the country have extended their whole hearted support. Latterly, however, the failure of the machinery to get in motion has led to inquiries and these inquiries disclose that among certain members of the administration political considerations quite evidently are not being disregarded even in the vital matter of national defense. Revelation at the end of July that not a single bomber, pursuit or combat plane had been ordered came as a distinct shock to the country though not more so than the explanation that delay was due to failure to adjust the matter of tax amortization on new plant facilities. While this is something that could be remedied in a day or two by Congress it appears that administration officials are insisting that the question shall be dealt with only as a part of the general revision of the excess profits tax.

The same condition that hampers the air defense program holds up orders for armor plate, tanks and other equipment that will be needed in large quantities. In the placing of contracts there is reported an insistence in high quarters that they be distributed to cover a large number of separate plants some of which are ill-prepared to cope with the tasks entrusted to them instead of being concentrated where the equipment exists to turn out a large supply of products in a relatively short time. Many other instances are being cited in which the efforts of members of the ACND and their assistants to get prompt and practical results are being delayed or thwarted because they do not conform to the pet theories of politically minded members of the administration or to their views of what will be of partisan advantage.

Another phase of this same tendency to pursue political objectives regardless of the effect upon the preparedness campaign directly involves the petroleum industry. Oil is recognized as a vital factor in modern warfare, no less essential than the ships, planes and mechanized land equipment which are useless without it. Mobilization of the oil resources of the nation figures importantly in the plans of the Defense Commission. The industry is being called upon to give its best efforts to the task of national preparedness which its members are voluntarily and gladly doing.

This critical juncture in the nation's affairs was the time selected by the Attorney General of the United States and his lieutenant, Thurman Arnold, to announce that they were about to file suit against twenty-two of the largest oil companies in the country. This, it must be borne in mind, was to be no ordinary prosecution. It was the big push which Mr. Arnold has long been preparing against an economic organization evolved from long experience and effectively serving the public interest. It was advertised as designed to smash the companies, to force the separation of marketing, transportation, refining and producing operations. If successful it would force a complete reorganization of the oil industry, increase the cost of its products to consumers and inevitably impair its efficiency as an adjunct of national defense.

That the suit was being brought in the midst of a presidential campaign when the attendant possibilities of arousing class feeling against capitalistic organizations could be turned to the political advantage of an administration striving to succeed itself may be a mere coincidence. Yet critics are bound to regard the timing as significant.

For the moment at least the projected blitzkrieg has been delayed by the protest of the Defense Commission that the action, if successful, "would require substantial changes in the entire economic set-up of an industry considered basic to the national defense". In announcing that the suit was being postponed Attorney General Jackson was careful to explain that it was done after consultation with the commission but not at the request of any commission member. Nevertheless it appears that the punitive hand of the Department of Justice was stayed directly by the request of the commission for time to determine the effect of the prosecution upon the program of national preparedness. The Attorney General says in fact that no decision will be made as to authorizing the action until the commission is in a position to report on this point.

Thus, the oil industry will be permitted, for a brief

time at any rate, to cooperate effectively in the work of preparing the national defense, but all the time the axe will be kept hanging over it as a grim reminder of the real purposes of the federal administration.

United States Position Still Critical

WHILE it would be unduly optimistic to describe the petroleum situation in the United States at the beginning of August as satisfactory, certain definite signs of improvement have made their appearance within the past few weeks. Most important of these unquestionably has been a reduction, moderate but encouraging in the daily rate of crude oil production and indications that this will continue during ensuing months.

During the first five months of the year, production was at the rate of nearly 3,800,000 bbl. daily or over 350,000 bbl. above the corresponding period of 1939. This was a gain of 57,000,000 bbl. or over 11 percent. At the same time domestic demand for all products increased at very nearly the same rate, over 10 percent, but the sharp falling off in exports nullified half of this gain so that the net increase in total demand was only five percent.

As a result of this unbalance, stocks, both crude and refined, recorded an unsettling advance over the sufficiently high levels which they held at the beginning of the year. Gasoline stocks reached the unprecedented figure of over 103,000,000 bbl. at the end of March and were still 90,000,000 bbl. at the beginning of August. This over-supply was the most disturbing factor in the situation. It was the cause of constant uncertainty in the distributing trade and of frequent displays of weakness in the price structure.

Since the strengthening of the gasoline situation could come only through a reduction in the high rate of production, the drop to a daily average of 3,600,000 bbl. in June was regarded with satisfaction which disappeared, however, when the production curve turned upward again at the end of July. It was then that proposals for more definite action to keep production in line were put forward. The Texas Railroad Commission, at its meeting on August 1st, however, decided that an extra two day shutdown, in addition to the five non-producing days now in effect, was sufficient curb for the time being. Meanwhile, Illinois production took a drop of 65,000 bbl. which most authorities believe will be maintained. With a moderate reduction in California and a few other states, it is believed that production for the next few months can be kept within the limits of the Bureau of Mines estimates of requirements.

On the unfavorable side is the virtual embargo on exports which will cause a further constriction of the market, the extent of which can be judged by the fact that during the first half of the year, exports still averaged over 10,000,000 bbl. monthly. To maintain an equilibrium for the balance of the year will require concentrated effort to keep production within bounds, a necessity to which the industry seems now to be alive.

War Hits Venezuelan Exports

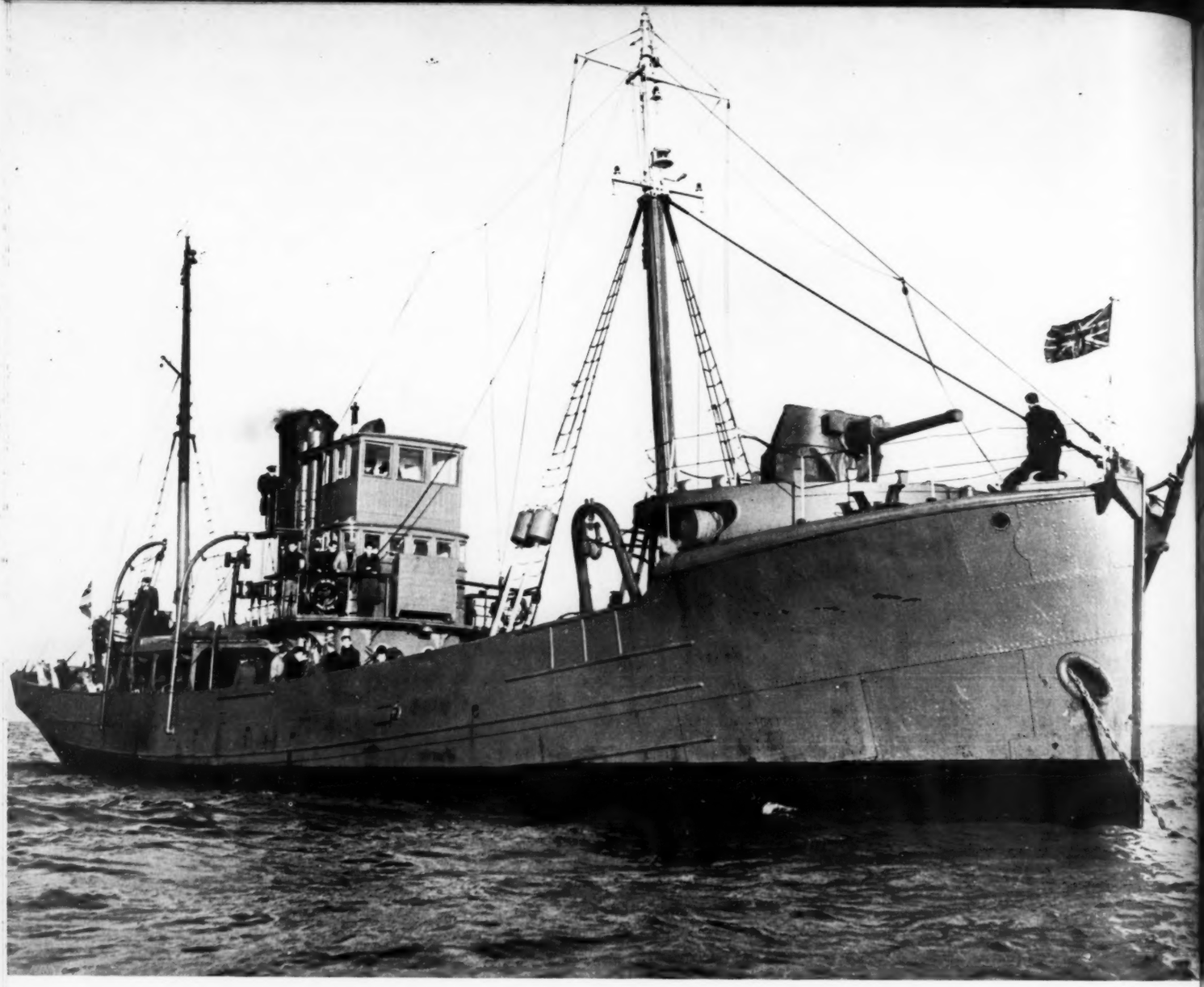
UNDER the influence of war and blockade the trade of exporting countries in petroleum products has been badly shattered. With the whole European continent, including all the leading importing nations except the United Kingdon, closed to international commerce the situation has become greatly aggravated within the past two months.

Probably nowhere is it being felt more severely than in Venezuela which is third among the countries of the world in volume of production but is first in the extent and value of exports.

Out of Venezuela's annual production of 200,000,000 bbl. of crude oil 90 percent is consumed outside the country and of these exports by far the larger part has found its markets in Europe. As the course of the war has eliminated one after another of these markets sales and shipments have fallen off. While the companies operating in Venezuela have striven to find new outlets and have increased shipments to North America as a partial measure of relief the continued slackening in demand has at length forced a curtailment in production.

While the reduction thus far has amounted only to about 10 percent of the normal daily output the possibility that it may have to be carried further naturally has caused great public concern. It involves a loss in national revenues, in wages and in other oil industry disbursements on which the economic welfare of the country so largely depends. Unfortunately no alternative to the temporary reduction of output appears possible. To go on producing oil for which there is no market and no means of storage is out of the question. Even if storage facilities were available to take care of excess production the piling up of surplus stocks would lead inevitably to a destruction of values through price demoralization that would inflict an economic loss far greater than will result from present restriction of production.

A reassuring feature of the situation is that the oil companies in consultation with officials of the government, are taking whatever steps are possible to make those readjustments that are inevitable in such a way as to keep unemployment at a minimum and to prevent undue disturbance of the national economy. While conditions created by forces entirely outside the country may impose some sacrifices on the nation as a whole as well as heavy losses on the oil companies it appears that the situation is being dealt with in a broad-minded effort to avoid national injury to the greatest degree possible.



Ⓒ British Combine

National Committee Plans Oil's Part in DEFENSE

Increased Production of Aviation Fuel, Transportation and Storage for Air Use Receive Special Consideration - May Call on Industry to Supply Toluol and Synthetic Rubber.

WASHINGTON

INCLUSION of aviation gasoline, lubricating oil and tetraethyl lead under the export licensing controls authorized by the Navy "speed-up" act of July 2 is the major development in a series of national defense plans affecting the petroleum industry now under consideration here.

Aside from its immediate and obvious implications with respect to foreign policy the order apparently is the fore-runner of projects designed to obtain and maintain at all times a supply of high octane gasoline ample for the national defense. It further envisions the development of special storage facilities for defense needs and possibly the construction of one or more gasoline pipelines from the mid-continent fields to the eastern seaboard.

Under the presidential proclamation, dated July 26 extending the export license list first announced July 2, the items of interest to the petroleum industry are defined as follows:

Petroleum Products. (a) Aviation motor fuel, i.e., high octane gasoline, hydrocarbons and hydrocarbon mixtures (including crude oils) boiling between 75 degrees and 350 degrees F. which with the addition of tetraethyl lead up to a total content of 3 c.c. per gallon will exceed 87 octane number by the A. S. T. M. knock test method; or any material from which by commercial distillation there can be separated more than three percent of such gasoline, hydrocarbon or hydrocarbon mixture. (b) Aviation lubricating oil, i.e., any lubricating oil of 95 or more seconds Saybolt Universal Viscosity at 210 deg. F. with a viscosity index of 85 or more. (c) Tetraethyl lead. Pure tetraethyl lead,

ethyl fluid, or any mixture containing more than 3 c.c. of tetraethyl lead per gallon.

A definite plan for obtaining sufficient 100-octane aviation gasoline for defense purposes has been worked out by the National Defense Advisory Commission under the direction of Dr. Robert E. Wilson, by which the government will purchase and store enough of the special motor fuel for approximately 100 days of "major effort". That has been defined as war and the use of all the aircraft the military establishment may have acquired within the next two years.

thus increasing production capacity without large new investment. At present 100-octane gasoline is used only by the army and navy and the Pan-American airways, plus what is exported to Great Britain. The plants capable of its production admittedly have not been working at capacity.

As the huge airplane program of the army and navy shapes-up toward the goal of 25,000 planes of all types in two years the requirements for 100-octane gasoline will increase rapidly although primary training planes will continue to use lower grades of gasoline. It has been possible, therefore, for the National Defense Advisory Commission to make a rough estimate of supplies of gasoline needed, during the next two years either for training or for the "major effort". After a year or more these estimates can be changed if it is found necessary. In a recent progress report Edward R. Stettinius, Jr., a member of the National Defense Advisory Commission in charge of the materials division stated:

> "Various units of the petroleum industry have been informed of specifications and rapid progress is being made to assure adequate supplies properly stored to meet all demands."

The storage program when completed will provide a reserve of 100-octane gasoline sufficient to last for 100 days at the estimated rate of consumption in war-time. Productive capacity will be at a rate to supply about 50 percent of the gasoline needed during war, and since exports would be shut off immediately it is figured that the military forces could get along without any shortage until new refining equipment could be built, which would take about nine months.

Instead of providing for additional refining capacity at this time to turn out 100-octane as fast as would be consumed during a war, it was decided that it would be reasonably safe to let capacity remain at about 50 percent, of war demand and to use available funds for building up reserve storage. As envisioned here much of the storage space will be underground, either in concrete reservoirs or spheroid metal tanks, covered

The army and the navy plan to build storage facilities at air fields and supply depots to handle much larger supplies than have been carried in the past, but the bulk of the storage will be held in tanks built by the refiners with whom will be placed large contracts which will give them assurance that they can run at capacity for a year or more. The contracts will stipulate that the refiners build suitable storage space, possibly much of it underground, in which the fuel will be stored after sale to the government which will hold title and pay a storage charge presumably ample to amortize the cost of construction of the facilities. The capital invested also presumably could be depreciated for tax purposes in the manner which, it is expected, will be worked out, in the forthcoming excess profits tax bill.

The National Advisory Commission for Aeronautics has proposed slight changes in the specifications for 100-octane gasoline now used by the army and navy, and if current performance tests prove satisfactory the changes will be adopted. This will permit the production of acceptable gasoline by certain plants and processes not now in the business,

↑ © British Combine

Extreme left, British mine sweeper on duty to diminsh one of the hazards of warfare that affect non-military activities; U. S. Coast Guard cutters might be used for this service in the event of war. Above, armed British merchant vessel; the U. S. merchant marine would play a vital role in any conflict in the Western Hemisphere. Right, water transportation on the intercoastal waterways of the Gulf Coast could continue despite adverse or dangerous conditions at sea; here a tanker is seen on the Texas-Louisiana canal.

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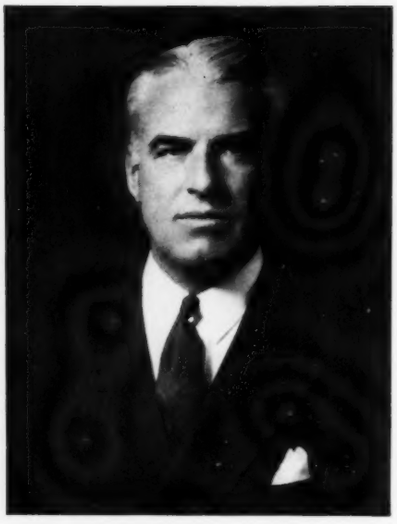


Industrial mobilization is being organized to serve as a huge reservoir supplying the army and navy: Left to right, the men intrusted with this gigantic task; Dr. R. E. Wilson, president of Pan American Petroleum and Transport, in charge of petroleum matters on the Advisory Defense Committee, E. R. Stettinius in charge of materials, and Ralph Budd in charge of transportation including pipelines. Upper picture, courtesy U. S. Navy Recruiting Bureau, portraits by Blank & Stoller.

with enough earth to sustain any thing short of a direct hit by a heavy bomb, and planted over with vegetation so as to make the exact location unidentifiable from the air.

Other storage will be above ground in special tanks in regular tank farms, since it is figured that while an enemy plane could easily bomb a tank farm the chances are slight that hits would be made on the particular tanks holding the reserve aviation gasoline. Companies contracting to build this storage space can obtain loans for the purpose from the Reconstruction Finance Corporation if they so desire.

Although no definite plans have taken form with respect to oil transportation problems the division of the National Defense Advisory Commission under Ralph Budd has designated Fayette B. Dow, Washington representative of the American Petroleum Institute, as an advisor with particular reference to pipeline transportation. It has been suggested that the defense commission may recommend the construction of a 12-in. pipeline from St. Louis to the eastern seaboard to put down aviation fuel directly and speedily at army and navy flying fields, airbases and depots now being developed along the Atlantic coast.

In this manner, it is pointed out, the military forces would be assured a supply against any eventuality which might cripple other forms of transportation including tanker movement from the Gulf ports, or damage to

refineries in the Atlantic coast area. Except for the hook-up with the flush Illinois fields, it is pointed out, through pipeline connections with the mid-continent field have not been numerous in the past few years.

The other petroleum products of immediate concern to the defense plans are toluol and synthetic rubber. The matter of toluol, essential in making T. N. T., has been taken up by the Coal Tar Subcommittee of the Chemical Advisory Committee of the army and navy Munitions Board and the Chemical and Petroleum sections of the Defense Commission. As a result a central office to receive proposals for the manufacture of nitratable grade toluene by responsible companies prepared for production of this product in large quantities within twelve months of a contract date has been established at Wilmington, Delaware, in charge of Major J. B. Harris of the Ordnance Corps of the army.

Most toluol comes from by-product coke ovens, though in emergency some could be recovered from city gas plants. In recent years an impure grade of toluol has been produced as a by-product of certain petroleum cracking processes, and while this is useable in making lacquers and some other processes it does not combine readily with nitrogen for making explosives.

According to defense commission experts, processes are now being perfected to synthesize pure toluol from petroleum by changing the straight carbon chain to the benzine ring characteristic of toluol and other coal-tar chemicals. Another possible source is the extraction by refining processes of toluol present in certain special petroleum products. It is believed that these processes are entirely satisfactory and that the petroleum industry can be relied upon as the source of sufficient nitratable toluol for all war-time needs.

In discussing toluol, Mr. Stettinius said:

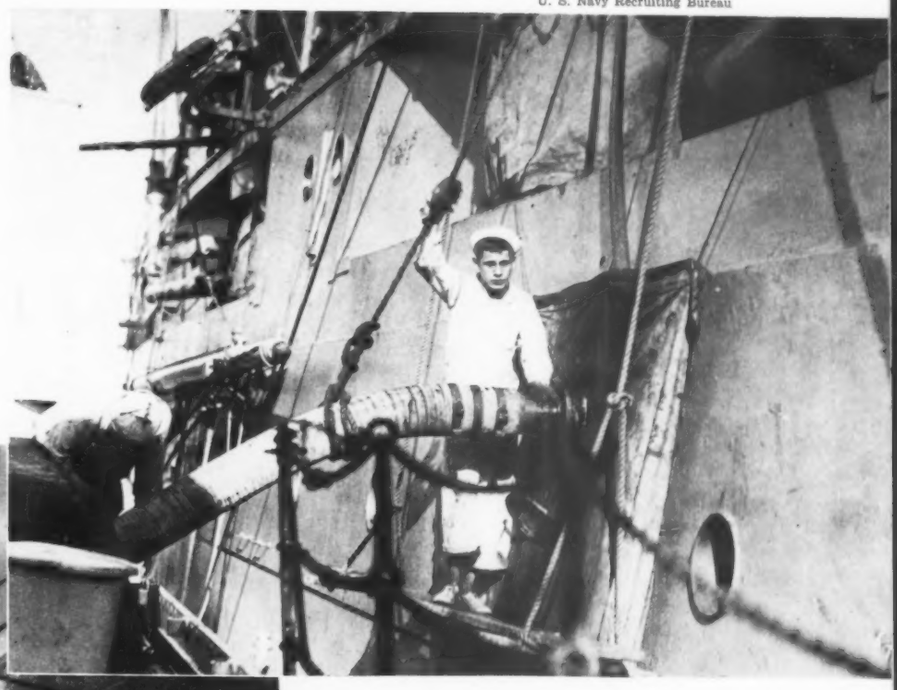
"We find industry has given considerable thought to possible requirements and has made plans for development processes to meet defense needs. A large part of production will come from the petroleum industry which has never before produced this material commercially."

Plans for increasing the production of synthetic rubber, whether from petroleum products or other materials, are being kept secret for the time being, but more information probably may be released soon.

Oil Industry's Part In NATIONAL PREPAREDNESS

The U. S. Oil industry can supply sufficient fuel oil for a navy several times larger than the proposed U. S. naval expansion program without radical change in present organization.

U. S. Navy Recruiting Bureau



American Petroleum Industry Fully Equipped to Meet Any Demands Made Upon It by Expansion of Armed Forces or by War Itself - Can Provide Enlarged Facilities from Own Resources without Government Assistance or Control.

IN LAUNCHING a movement of national preparedness for defense such as has been put under way in the United States within the past few months a necessary first step is a survey of resources and industries to determine the material available and the means for its utilization. Such a survey is now being conducted by the federal government through its own departments and agencies and through the recently established Advisory Defense Committee, on which E. R. Stettinius, is in charge of materials.

As special advisor on petroleum matters Dr. Robert E. Wilson, president of Pan American Petroleum and Transport Co., has been named and other members of the industry have been appointed to various committees. Secretary of Interior Harold Ickes has ordered a survey of petroleum resources to be prepared under the direction of George Holland, head of the Interior Department's petroleum division, and the Bureau of the Census in the Department of Commerce is collecting statistics covering the oil industry among others.

Several purposes are in view in this national inventory. The primary object of course is to discover what the United States has in the way of the essential materials for national defense and what facilities it possesses for turning these materials into finished products. Where raw materials are lacking means of obtaining them or substituting others will be worked out. Where manufacturing plant is deficient it will be determined whether this can be supplied by private capital within the industry concerned, whether the financial assistance of the federal government is needed in order to provide the necessary capacity promptly or whether the nature of the task is such that it can best be performed by the government itself.

The numerous studies now under way will provide the federal authorities with a vast amount of official information regarding the essential industries of the nation. They undoubtedly will reveal many points in the industrial structure that will need strengthening in order to carry out the elaborate program of armament and preparedness that has been laid down. So far as concerns the petroleum industry the data being assembled will serve a useful purpose by providing full information regarding the industry in official form. The important facts regarding the oil resources of the country and the machinery for their utilization are readily available, however, and it can be said in advance of the conclusion of official studies that these will reveal few if any weak spots in its equipment for national service. Not only is the industry prepared to meet any extraordinary demand put upon it by the requirements of national defense but it is well able to expand its output, its manufacturing facilities and its production of specialized products through its own resources and without assistance of the government or intervention by federal authorities except to be told the extent of the government's own requirements. Some special storage facilities at strategic points probably will be provided by the government as a matter of preference.

PRODUCTION

The leading position of the United States in oil production is well known. Petroleum in fact is the most important mineral product of the country. Certain facts in relation to the industry's ability to meet increased demands, either in support of an enlarged army, navy and air force or for the prosecution of war itself, may be recapitulated, however.

With an annual output of 1,250,000,000 bbl. of crude the United States produces over 60 percent of the world supply of oil. In addition to supplying the rapidly growing needs of the domestic population the industry exports in normal times 150,000,000 to 175,000,000 bbl. of crude and products annually. A reduction of exports would make it possible to meet defense requirements without any diminution of domestic peacetime consumption. On the other hand a reduction of 10 percent in private consumption of gasoline and fuel oil which could easily be effected without serious inconvenience or loss of industrial efficiency would release over 50,000,000 bbl. of each of these products annually which would go a long way toward meeting purely military requirements even in a highly mechanized war.

While current production of crude is some 3,500,000 bbl. daily it would be a simple matter to increase this by another million practically at a moment's notice simply by lifting the restrictions now imposed either through voluntary control or by the regulations imposed by official bodies in Texas and other oil producing states. While such action if long maintained might be damaging to the program of conservation now well established in many parts of the country it represents an emergency resource of important proportions.

Back of these immediately available supplies of tremendous porportions are proved reserves of nearly 18,000,000,000 bbl. These known reserves are increasing year by year and have more than tripled in the past fifteen years. The satisfaction of current demands and the expansion of proved reserves are served by a constant campaign of new drilling in established fields and of wildcat exploration for the discovery of fresh producing areas.

In connection with reserves, officially estimated at 18,000,000,000 bbl. it is interesting to note that Prof. Lester C. Uren, writing in the July issue of WORLD PETROLEUM, calculates that there is an additional reserve of between 67,500,000,000 and 110,000,000,000 bbl. of oil that has been left in known fields as physically or economically unavailable under past operating conditions. Prof. Uren suggests, that while some of this oil is obviously unrecoverable, increased economic incentive might well lead to production of at least a third of this huge reserve with no more advanced technology than is presently available. On this basis therefore, the United States might be said to have in sight, in addition to the 18,000,000,000 bbl. official reserve, somewhere between 22,500,000,000 and 36,500,000,000 bbl.

The average number of wells drilled in the United States during the past five years has been above 27,000 annually. Some 2[illegible] percent of these are dry holes and a certain number of wells are abandoned each year because of exhaustion or a drop in yield which makes their operation commercially impracticable. The total number of producing wells grows from year to year and is now approximately 375,000. The annual expenditure of the oil industry on geological and geophysical exploration and on drilling is estimated at well over $500,000,000. At the present time the tempo of drilling activities is rising and some 15,000 wells were drilled in the first six months of 1940.

One of the strong features in the production position of the United States is the location of its petroleum deposits. The great producing areas are situated along the Gulf Coast in Texas and Louisiana, on the Pacific Coast in California and in the Mid-Continent, with a substantial proportion in the eastern and east central states. Ample supplies are located at points of strategic importance and could be quickly moved to the ports and other defense positions where they would be needed in time of war. All producing sections in the interior of the continent are connected to coast cities and important consuming centres by a network of pipelines that permits the rapid movement of either crude or products to any point where they may be needed.

Likewise, the wide distribution of production, extending over eighteen states reaching from the Atlantic to the Pacific, offers the great advantage from the viewpoint of defense that the greater part of the industry would be immune from damage unless the entire country were to be overrun by invading forces.

REFINING

Possession of abundant supplies of crude, while a primary requirement in a preparedness program, would be of little avail without adequate facilities for converting this raw material into the products needed for fueling planes, tanks, trucks and ships. In this respect the oil industry is as completely equipped as it is on the side of production.

In addition to the refining capacity needed to supply regular domestic and export requirements there exists in the United States at all times a substantial unused capacity. In the whole country there were on January 1, 1940, 561 refineries of which 431 were active, 120 were shut down and 10 were under construction. While average runs to stills are roundly 3,300,000 bbl. daily the available capacity is 4,600,000 bbl. While some of this idle equipment capable of handling 1,300,000 bbl. daily is partially obsolete by current operating standards most of it is capable of being used to satisfy any urgent need that might arise for the ordinary run of refined products.

Military requirements, however, whether in routine operations or actual warfare, are for certain specialized products. An enlarged air

force will call for greatly increased quantities of 100 octane gasoline. Should the mark of 50,000 planes suggested by the President be reached consumption of aviation fuel by the various branches of the service might rise by 10,000,000 bbl. yearly. The extent of 100 octane production thus far has been much less than this figure, not because of inability of the oil industry to supply larger quantities but because the demand for it did not exist.

Production of aviation fuel in the United States is at the rate of about 900,000 bbl. monthly. Domestic demand is a little less than half this. Export demand formerly absorbed most of the remainder but since the beginning of the current year the export trade had fallen away sharply. As a consequence, stocks have been rising. They are now above 4,000,000 bbl., approximately a six months domestic supply as compared with 2,400,000 bbl. in October last when separate statistics on this class of fuel began to be collected regularly.

In this particular field, however, it seems that the oil industry has been working with almost prophetic vision. Within the past few years research in the refining branch of the industry has been directed very largely to devising means and methods for increasing the production of high test fuel, particularly for use in air navigation, and lessening its cost. The result has been a succession of new processes that have followed one another so rapidly that it is confusing to the non-technical man to attempt an understanding of all their characteristics and the distinctions between them. Hydrogenation, polymerization and catalysis, with numerous variations of each, have converted former wastes into products of the highest usefulness, have improved gasoline yields and quality and have put the United States far to the fore in ability to provide what may properly be described as the fuel of the future. At the present time no other nation can approach the United States in potential production of 100 octane gasoline. None other in fact can produce it in quantity sufficient to supply its own wartime needs.

Progress through the development of still other new processes or in the improvement of existing ones is by no means to be presumed at an end, but some two-score plants are equipped to turn out the highest test fuel that the most advanced airplane engines can use. Installation of new units capable of producing much larger quantities than ever before have been used can take place far more rapidly than engines to consume the fuel can be manufactured. Fortunately America's hundreds of refineries provide a vast supply of the gases which under the various forms of treatment referred to yield superior fuels of 100 and higher octane. American fields produce oils of the widest range in gravity, base and composition so that the best material for any desired type of product is always available.

In the building of an efficient air armada it is quite as important to have a superior type of fuel as it is to have well designed planes and powerful engines. The important part played by the motor fuel is indicated by the

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frequently used comparison that a plane fueled with 100 octane gasoline can carry twenty to thirty percent more load, can develop twenty to thirty percent higher speed and can climb twenty to thirty percent faster than the same machine using 85 octane fuel. Superiority in speed and maneuverability is often a vital factor in aerial combat. Through the facilities which it has developed for producing the highest type of fuel in whatever quantities required the oil industry has given to the United States a highly important advantage in undertaking the expansion of its air power.

One lesson convincingly taught by the past year's experience in Europe is the advantage under present day conditions of using to the greatest extent possible motorized equipment both on attack and in defence. Trucks for the movement of men and materials; tanks as offensive and defensive weapons; mobile field artillery and anti-aircraft guns—these are primary factors in the efficiency of land forces. They all depend upon liquid fuel—gasoline or Diesel oil—and the measure of the growth in this requirement is indicated by the fact that the horse-power employed by a mechanized division today is fifty times as great as was the case with the so-called mechanized divisions in the first world war.

In the plans of the United States for creating a larger and more mobile army great additions to motorized equipment will be required, but to meet the greater fuel requirements of such a force will impose no strain whatever upon the present organization of the American oil industry. In the event of actual hostilities the employment of refining capacity now unused or additions to existing plants that could be quickly constructed would meet all possible needs.

Doubling the size of the American navy, a most important phase of the preparedness program, would double the Navy's consumption of fuel oil which is now around 9,000,000 bbl. yearly. In actual warfare the rise in consumption would be much greater. As the country's annual consumption of heavy fuel oil is around 350,000,000 bbl. the diversion of less than three percent of this amount to naval use or an increase of this small percentage in total output would present no serious difficulty. Exports of this type of fuel oil in recent years have just about equalled the consumption by naval vessels.

Other petroleum products required in relatively large quantities by enlarged military, naval and air establishments are lubricating oils and greases and petroleum wax. These are products which the United States regularly exports in large volume. The superior quality of American lubricants has enabled them to find and hold markets in all parts of the world. While Pennsylvania has long held a leading position in the production of high grade lubricants modern developments have made it possible for other oil producing districts to compete in this field and have vastly enlarged the potential producing capacity for these products. This capacity is now adequate to meet any demand that an armament program or war itself could put upon it.

TRANSPORTATION

For the movement of crude from fields to refineries or ports and for the transfer of products to marketing centres or to other points where they may be needed an elaborate system of transportation has been developed. Oil moves preferably by water routes since this is the cheapest form of transport. Where it is not available, pipelines are employed as an efficient and economical means of conveyance between points where there is a steady and substantial flow. Railway tank cars and motor trucks supplement these two main methods for local distribution or in places where the volume is insufficient to justify the construction of pipelines.

Nowhere else in the world is there such an extensive system of pipelines as in the United States. From the Rocky Mountains eastward to the Atlantic and southward to the Gulf coast, they extend in a vast network, connecting all important producing fields with refineries, shipping ports, and distributing points. The Pacific Coast has it own system. The pipeline mileage for the whole country is 115,000 and its total capacity roundly 25,000,000 bbl. In the course of a year something like a billion and a half barrels move through the pipelines of the country.

Pipeline systems are of two main classifications. Gathering lines collect crude from the local fields of each producing area, and convey it to storage tanks at convenient shipping points or to nearby refineries. In the aggregate the extent of these lines is greater than that of all others, amounting to nearly 60,000 miles. Their function is most important, assuring a constantly available supply of crude which can be fed to refineries and shipping points according to their needs.

The second group of pipelines is made up of the great trunk systems linking the big fields of Texas and the Mid-Continent with refineries along the Gulf coast, in the Middle West

Photo by U. S. Army Signal Corp

and on the Atlantic Seaboard. Through these lines flow great rivers of oil fed by the tributory streams of the gathering systems and enabling the whole refining system of the country to operate without danger of interuption.

Eighty percent of all the crude handled by refineries in the United States is carried by pipelines. A comparatively modern development is the utilization of this same method of transportation for manufactured products. A number of lines built originally to carry crude are now being used to convey gasoline in the reverse direction while other lines, hundreds of miles in length have been constructed exclusively as gasoline carriers.

Close to a billion dollars of capital is invested in pipelines in the United States. The services of these lines, essential to the ordinary commercial operations of the oil business, become invaluable in equiping the industry as an agency of national defense and enabling it to meet any emergency that may arise.

The greatest single division of the world's merchant fleet consists of ships engaged in the petroleum trade. Of these approximately 2[illegible] percent belong to American companies, a greater number than are operated by any other one country. The larger part of this tonnage is employed in the coastwise trade of the United States, from the Gulf to Atlantic seaboard cities and between the east and west coasts through the Panama Canal. While the volume of traffic moving by boat is less than that conveyed by pipe line hundreds of millions of barrels of crude and products traverse the seas on both sides of the continent and its interior lakes and rivers.

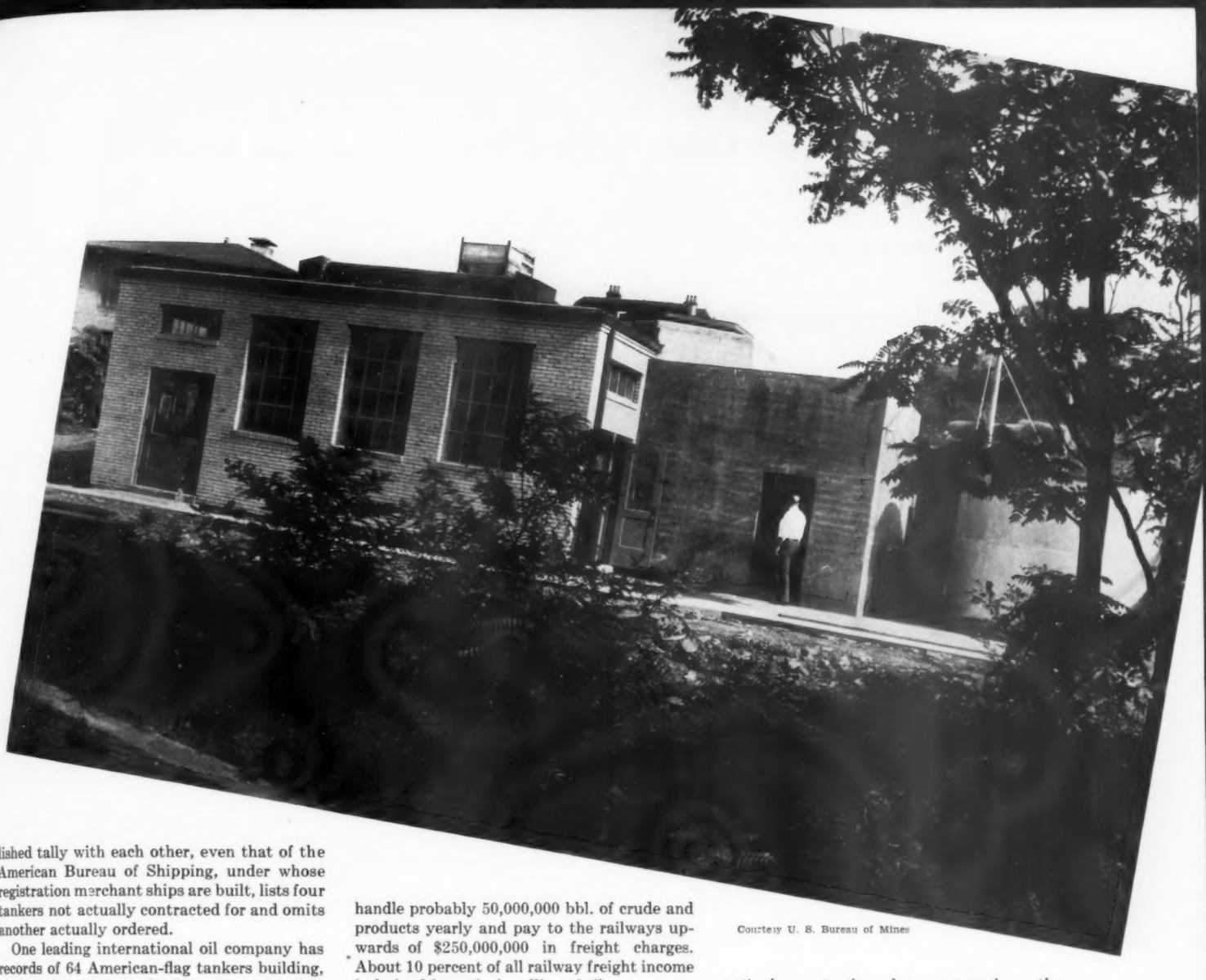
Without counting American-owned tankships sailing under the flags of other nations, there were in service or available for emergency operation at the end of July, a total of 376 vessels aggregating 4,375,000 deadweight tons and operating under the American flag, not counting craft of under 4,000 tons dw.

Over two years ago the collaboration of the U. S. Navy Department with the U. S. Maritime Commission and the Standard Oil Company, (N.J.), resulted in the latter ordering twelve 16½-knot tankers of 16,000 dw. tons each. This was the first preparedness attempt to meet possible war conditions. Plans and details were published in WORLD PETROLEUM of February, 1939, the cost price for the 12 vessels being $37,566,004 of which the oil company provided $27,063,004 although it then had a construction program of ten 13-knot, 13,000-tons dw. ships building at a cost of $13,000,000. Several of the larger tankers have since been acquired by the Keystone Tankship Corporation.

Since then, the tendency of American oil companies has been toward building larger and faster tankers, and the power of most of the ships recently ordered is 7,500 to 12,000 h.p., compared with a previous average of 4,000 to 5,000 h.p. Speeds have gone from 12 knots and now are as high as 18 knots, which speed a few years ago was generally regarded as impractical and uneconomical for bulk oil vessels.

While there exists no secrecy as far as ship construction in American yards is concerned, it has been difficult to obtain the exact number and tonnage of tankers now building or on order because none of the several lists pub-

An impressive fleet of coastwise tankers brings fuel to the mechanized divisions now being organized in the U. S. Army. Above right, despite huge reserves of readily available oil the U. S. government continues experiments with hydrogenation of coal in this Pittsburgh experimental station.



Courtesy U. S. Bureau of Mines

lished tally with each other, even that of the American Bureau of Shipping, under whose registration merchant ships are built, lists four tankers not actually contracted for and omits another actually ordered.

One leading international oil company has records of 64 American-flag tankers building, aggregating 979,060 deadweight tons; while another large oil company quotes 67 tankers totalling 1,003,600 deadweight tons on order as of the end of June, of which two have since been delivered; while the American Bureau of Shipping gives 68 ships aggregating 654,770 gross tons.

Careful checking, however, shows that now on the ways or on order are 61 tankships of over 4,000 deadweight tons, aggregating 932,420 tons deadweight capacity. This gives an average of 15,285 tons per vessel. As the construction costs range from about $130 to $190 per deadweight ton according to the speed, the total amount invested in new construction amounts to the very substantial figure of $56,000,000 and probably more.

Most of the large tankers now on order are steam propelled, only 12 being Diesel driven. Two have turbo-electric power, but none are equipped with the Diesel-electric system which it will be recalled has been introduced with satisfactory results on vessels of the Atlantic Refining Company's fleet.

Third in importance among the agencies of petroleum transportation is the railway tank car. Some 150,000 of these cars are in regular service on American railway lines. They handle probably 50,000,000 bbl. of crude and products yearly and pay to the railways upwards of $250,000,000 in freight charges. About 10 percent of all railway freight income is derived from the handling of oil.

This network of transportation facilities, supplemented by huge terminals and bulk storage stations at all important distributing points, keeps the oil industry constantly in a fully mobilized position, ready to supply, virtually at an instant's notice, large quantities of any of its products whenever they may be needed.

The only remaining factor needed to enable the industry to meet requirements of a vastly augmented preparedness campaign, or of war itself if it should come, is an organization to coordinate its activities, prevent waste motion and avoid needless duplication of effort. Such an organization was provided by the industry itself at the time of the first world war. It consisted of a committee representing all branches of the industry which was set up at the request of the federal government. At that time the task of first importance was to provide and transport overseas the supplies of oil vital to the operation of the Allied fleets and armies. The work was carried out with such speed and success that it was credited with a large share in the ultimate victory of the Allies.

In the present movement, to insure the nation's protection from aggression, the problem is fundamentally the same, but differs in details. Full cooperation of the members of the petroleum industry will be forthcoming, but it will be necessary to provide some assurance that consultation and cooperation among them to serve the public needs will not be made the basis of criminal prosecution by the law enforcement division of the federal administration. The Madison experience is still fresh in the recollection of oil men.

Already the National Defense Committee has called to its assistance some prominent representatives of petroleum. No doubt the liaison between the government and industry will be broadened in scope as the defense program develops. The important fact revealed by a survey, however, is that oil is one industry that is fully prepared, that the facilities needed for its contribution to national protection have been developed by the industry itself and can be expanded to any extent necessary from it own resources without assistance from public funds, and that the industry can function effectively under its own leadership with a minimum of government interference or surveillance.

U. S. Production Outruns Rise in Demand

Domestic Consumption of Petroleum Takes Strong Upward Swing in First Half of 1940 but Crude Output Rises Still More Rapidly—Motor Fuel Demand Up 7.7 Percent — Exports Fall Sharply — Imports Gain.

DOMESTIC demand for all petroleum products in the United States during the first six months of 1940 was 10.6 percent greater than in the corresponding period of 1939. According to statistics of the Bureau of Mines total domestic demand in the period January-June 1939 was 581,805,000 bbl. With official figures available for the first five months of this year and with June estimated on the basis of weekly reports the demand to June 30 was approximately 643,710,000 bbl.

This unusually large increase has been counter-balanced to some extent by the drop in exports which declined from 93,896,000 bbl. in the first half of 1939 to 64,668,000 bbl. in the same period this year, or roundly 30 percent. The combined domestic and export demand during the first six months of 1940 was 708,378,000 bbl. as compared with 675,601,000 bbl. in the same months of 1939, an increase of just under five percent. This corresponds closely with the rate of increase estimated by oil industry statisticians at the beginning of the year although the increase in domestic demand and the decline in exports both have been greater than was anticipated.

A gain of five percent in consumption might be expected to result in a satisfactory business situation for the oil industry. Unfortunately the increase of 350,000 bbl., over 10 percent, in daily crude production has outstripped the growth in demand and, together with a rise of 9,800,000 bbl. in imports, has caused stocks of products to remain at a high level that has kept the market in a precarious state since the first of the year. It is this situation that state proration authorities have been seeking to remedy during the past few weeks.

Table I accompanying shows crude production by the principal producing states during the first five months of 1939 and 1940 with the changes between the two periods.

TABLE I

(Thousands of Barrels)

State	January-May 1939	January-May 1940	Gain or Loss Percent
Arkansas	8,000	10,545	+32
California	93,455	92,697	— 0.8
Illinois	26,632	63,551	+139
Kansas	25,250	25,980	+ 2.9
Louisiana	39,860	43,434	+ 8.9
Michigan	8,663	9,443	+ 9
New Mexico	15,543	17,027	+ 9
Oklahoma	70,873	66,048	— 6.8
Pennsylvania	6,992	7,734	+ 10
Texas	206,229	217,179	+ 5
Wyoming	8,096	9,874	+ 22
Others	9,191	12,693	+ 38
Total	518,784	576,211	+ 11.7

The most noteworthy contribution to increased production both actually and proportionately was made by Illinois with a rise from 26,632,000 bbl. to 63,551,000 bbl. or 139 percent. The next largest increase was that of Texas which, however, amounted only to 11,000,000 bbl. or five percent. In Oklahoma production declined nearly 5,000,000 bbl. while California also showed a very slight decrease and Kansas remained nearly stationary.

On the side of consumption the greatest proportional increase was that of nearly 25 percent in distillate fuel oil, reflecting the heavy demand for heating during the cold weather that marked the early months of the year. The distribution of kerosene gained nearly 5,000,000 bbl. or 18 percent. The increase in motor fuel demand has been evenly maintained every month since the beginning of the year and amounts to roundly 18,000,000 bbl. or seven percent for the half year period. Demand for heavy fuel oil has been in even ratio with that for motor fuel with a gain of 7.2 percent. The smallest advance has been in lubricating oils with a rise of only 5.5 percent, reflecting probably the somewhat limited increase in industrial activity. Table II gives a comparison of domestic demand for principal products during the first five months of 1939 and 1940.

War in Europe with the consequent shutting off of markets and trade routes has had a paralyzing effect on American exports of crude and petroleum products. How serious the decline has been is shown by the accompanying Table III in which shipments for the first six months of 1940 are compared with the corresponding period of the year preceding. As shown by this tabulation the decrease in shipments of principal products has been 30 percent in total volume and approximately an equal amount in value.

TABLE III

Change in U. S. Oil Exports

(In Thousands of Units)

	Jan.-June 1939	Jan.-June 1940	Percent Change
	(Barrels)		
Crude	34,390	26,416	−23.16
Aviation fuel	2,493	1,363	−41.31
Other gasoline	19,628	9,653	−50.82
Kerosene	3,596	3,988	10.9
Distillate fuel oil	15,392	10,572	−31.32
Residual fuel oil	8,055	6,354	−21.13
Bunkers	18,589	.....	.....
Lubricating oils	5,215	6,697	28.42
Not otherwise specified	.....	4,466	.....
	(Pounds)		
Lubricating grease	47,871	71,456	49.29
Liquid gases	7,496	5,630	−24.89
Paraffin wax	124,912	116,572	−6.67
	(Tons)		
Asphalt	107	113	5.60
Coke	105	77	−26.16

It is noteworthy that the falling off in purchases by outside countries applies not only to belligerent nations but to neutrals in almost equal degree and extends to all important products except lubricating oils and greases in which there has been a substantial increase. The heaviest decline has been in gasoline, but fuel oils, kerosene and crude oil all show decreases of nearly 40 percent.

Canada retains its place as the principal purchaser of United States crude and shipments to that country were slightly larger during the first half of 1940 than in the corresponding period of 1939. France, Japan and Italy which ranked in that order, following Canada, reduced their purchases by 6,000,000 bbl. Shipments to the West Indies and South America fell to approximately one-half their former volume. The only European country that increased its takings of crude was Portugal. Two important European customers for American crude, France and Italy, have now been eliminated from the market by the development of the war. Stocks of crude and products accumulating

TABLE II

Domestic Demand

(Thousands of Barrels)

	Motor Fuel		Kerosene		Distillate Fuel		Residual Fuel		Lubricants		All others	
	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940
January	37,767	40,370	5,980	7,842	16,963	22,787	28,448	32,148	1,609	2,054	7,714	10,790
February	34,595	37,557	5,901	6,263	14,767	17,930	25,589	26,816	1,653	1,522	7,289	7,925
March	42,520	44,607	5,201	6,278	13,923	16,494	28,436	30,881	1,987	1,883	8,865	10,238
April	43,977	47,683	5,042	5,621	10,856	12,210	24,472	26,526	1,770	2,138	8,506	9,348
May	49,547	52,946	4,368	5,297	7,523	10,059	25,047	26,017	2,132	2,063	10,994	12,361
	208,406	223,163	26,492	31,096	64,032	79,480	131,987	142,388	9,151	9,660	42,975	50,671

TABLE IV

U. S. Exports Jan.–June By Products and Countries of Destination

(Thousands of Barrels)

Destination	Crude Oil		Gasoline		Kerosene		Gas and Fuel Oil		Residual Fuel Oil		Lubricating Oil	
	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940	1939	1940
Argentina	1,240	475	.....	5	.....	.....	.....	.....	.....	.....	8	33
Australia	.....	.....	407	477	32	98	16	25	.....	.....	242	336
Belgium	116	.....	600	109	58	12	521	104	38	10	387	253
Brazil	84	153	599	355	191	136	119	87	.....	.....	120	178
Canada	11,418	11,561	1,247	568	86	185	208	251	243	754	219	259
Chile	18	18	198	35	9	.....	106	285	800	.....	30	31
China	89	.....	65	218	119	233	238	35	91	.....	55	58
Cuba	601	535	309	354	1	.....	.....	.....	186	141	21	77
Denmark	156	.....	266	.....	230	.....	212	94	152	51	110	10
Finland	.....	.....	9	97	26	.....	53	.....	.....	.....	9	8
France	8,253	5,588	1,955	694	.....	.....	57	.....	.....	.....	211	331
Germany	416	.....	344	.....	17	.....	2,574	.....	.....	.....	699	.....
Guatemala	.....	.....	37	7	8	6	5	74	115	107	4	.....
Haiti	.....	.....	114	10	9	7	2	3	.....	.....	.....	.....
Hong Kong	.....	.....	121	40	55	29	159	49	91	.....	7	.....
Italy	2,900	1,420	224	60	13	.....	25	173	78	130	160	302
Japan	7,844	5,399	627	268	20	42	2,957	2,548	2,351	1,045	202	190
Kwantung	78	273	317	313	212	71	39	.....	.....	.....	22	11
Mexico	41	213	130	268	12	14	53	74	151	675	47	53
Morocco	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	6	.....
Netherlands	192	.....	850	328	507	182	1,664	189	386	.....	135	95
Netherland W. Indies	.....	.....	2,827	318	220	26	1,340	1,151	.....	.....	10	11
New Zealand	.....	.....	284	7	16	10	.....	15	89	6	52	76
Norway	15	.....	75	108	82	29	163	306	61	.....	18	57
French Africa	.....	.....	34	14	19	17	11	13	.....	.....	8	21
Spanish Africa	.....	.....	.....	.....	.....	.....	84	.....	312	.....	.....	.....
Panama Canal Zone	.....	.....	97	116	18	28	402	617	358	439	3	.....
Philippines	.....	3	624	605	262	202	234	182	388	310	50	72
Portugal	.....	291	364	71	122	.....	92	104	.....	.....	27	47
Spain	.....	.....	859	145	.....	78	312	641	385	965	77	257
Sweden	489	49	1,053	359	156	17	415	172	189	25	101	108
Switzerland	.....	.....	545	4	25	.....	108	.....	.....	.....	1	37
Turkey	.....	.....	181	.....	79	.....	58	.....	.....	.....	19	5
U. S. S. R.	.....	.....	.....	76	.....	.....	.....	.....	.....	.....	.....	.....
Union of So. Africa	.....	.....	136	22	.....	13	6	3	.....	.....	66	134
United Kingdom	275	2,259	5,480	2,257	685	236	2,781	2,247	199	299	1,557	2,446
Others	724	137	858	1,497	348	547	368	1,231	572	1,467	532	1,157
Total	34,949	26,416	21,876	9,785	3,596	2,139	15,392	10,572	8,055	6,354	5,215	6,688

at Gulf Coast points include many cargoes that normally would have crossed the Atlantic to Continental European markets which no longer can be reached.

Instead of the expansion in demand for gasoline which was anticipated at the commencement of the war the movement of this product has suffered a heavier proportional loss than any other. The only countries to which shipments increased during the first six months of 1940 were Cuba, Mexico, China and Spain, none of them among the more important importers of gasoline. Fuel oil exports have decreased less sharply than gasoline but have shared the general decline, the exceptions being the Panama Canal Zone, Mexico and Spain.

Aviation gasoline, for which a considerable increase in export demand was anticipated as a result of the war in Europe, is actually 42 percent lower during the first five months of 1940 than it was in the corresponding period of 1939. Obviously, stocks of this product for military use were being built up rapidly in 1939, whereas consumption has been somewhat less than was anticipated during 1940. Total exports of aviation gasoline for the first half of 1940 amounted to 1,768,193 bbl. Some 66 percent of the 1940 exports of aviation gasoline went to Europe, 13 percent to countries of the Western Hemisphere, 11 percent to Asia, Australia and Africa, and the remaining 10 percent to non-contiguous territories of the United States. Actual production of aviation fuel in the United States has averaged about 900,000 bbl. per month, or only 60 percent of capacity since October 1939, according to a report of the Director of the Bureau of Mines. Within the last three months there has been an upward trend in the production of this class of fuel. Domestic demand for aviation fuel has averaged about 400,000 bbl. per month and in May, 1940, export demand amounted to 415,000 bbl. which leaves some 85,000 bbl. in that month to be run to storage. Indeed, there is observable a steady trend toward increased stocks of this fuel, starting with 2,400,000 bbl. at the end of October, 1939, there has been a steady increase each month until at the end of May, 1940, there was on hand a quantity of 3,942,000 bbl. or approximately six months supply.

Contrary to the general trend exports of lubricating oil and greases have been heavier during the period January–June 1940 than they were in the corresponding period last year. Noteworthy gains were recorded in shipments to the United Kingdom, France, Italy, Spain and Australia. Lubricating oil shipments to Germany which amounted to 699,000 bbl. or 13 percent of all exports of this product in the first half of 1939 were of course entirely absent in 1940 and there were small declines in shipments to Netherlands, Denmark, Japan and a few other countries.

Tables III and IV portray the changes that have taken place in petroleum exports both as to total demand and shipments to various countries. While there are indications that continuation of the war in Europe may lead to some increase in the export movement during the final months of the current year and the early part of 1941 the resumption of normal trade must await the end of the conflict. Cessation of hostilities undoubtedly would bring a large temporary increase in export demand.

Imports of crude and products for domestic use, while a very minor factor in the general marketing situation, have been larger in the first half of 1940 than in the same months of 1939. Imports in bond for re-export have shown an opposite trend, declining 16 percent. Table V gives a comparison of imports for the two periods.

TABLE V

Imports to United States

(Thousands of Barrels)

	1939	1940
Crude in bond	1,831	590
Crude for domestic use	10,125	13,864
Refined products in bond	7,517	7,174
Refined product for domestic use	2,690	10,344

Tightening a stand of tubing on Union Oil's Alex No. 3 at Santa Fe Springs, California: photograph by Clarence Block, published through the courtesy of Axelson Manufacturing Co.

BIRTHPLACE Of Commercial Isooctane Doubled in Size

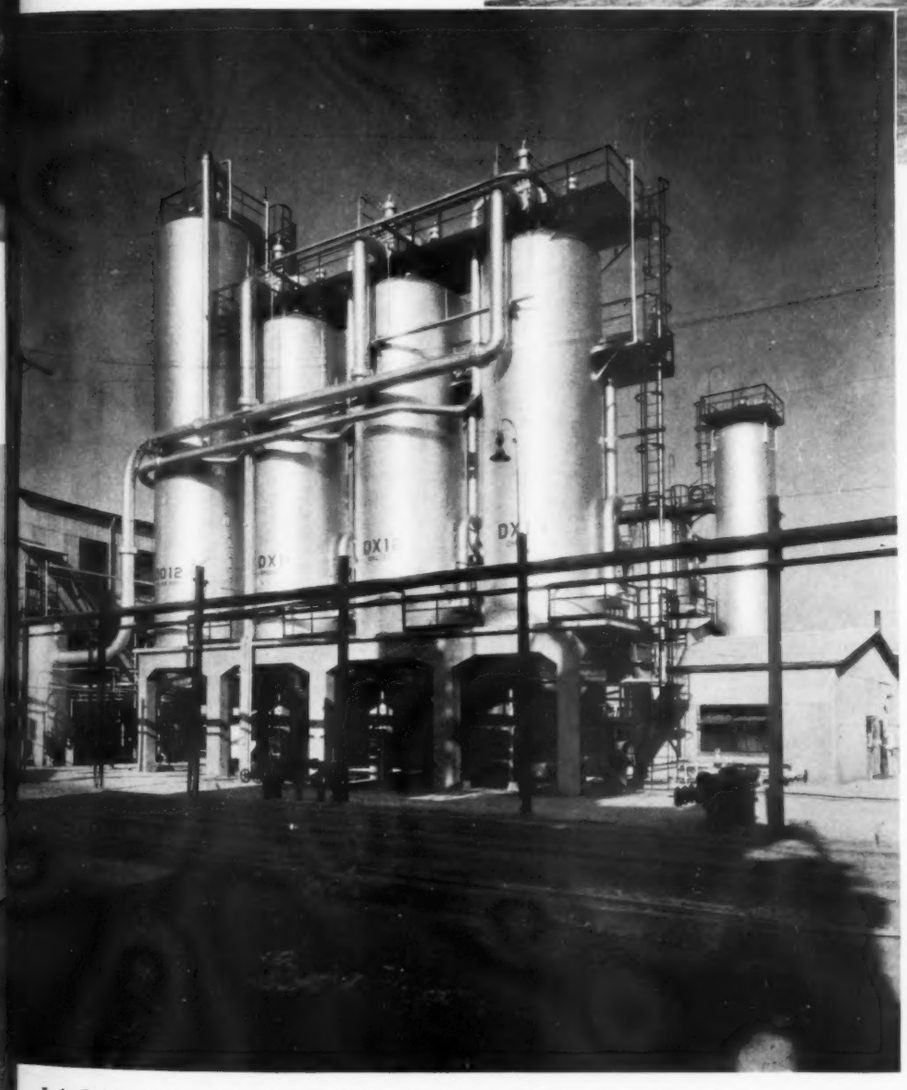
By Dr. O. W. Willcox

Herewith, Published for the First Time, is a Comprehensive Account of the Great Shell Refinery at Wood River. Long Known as the Source of Much Advanced Refinery Technique. An Extensive Program of Modernization Has Just Been Completed.

MODERN petroleum refining is characterized by two broad trends which generally run concurrently. On the one hand is a striving to keep pace with new developments by replacing old or obsolete equipment with improved designs, and on the other is the tendency to build larger units for the sake of the economies that result from conducting operations on a large scale. This latter tendency sometimes involves the consolidation of separate plants, so that with the major companies at least, the number of refineries tends to become smaller as the plants themselves become larger.

The 75,000 bbl. Wood River (Illinois) refinery of the Shell Oil Company, Incorporated, exemplifies these tendencies. Here is an old (relatively speaking) oil refinery that has been practically rebuilt and doubled in processing capacity within a period of twelve months.

Left, above, highway entrance to the refinery with manager's residence at right of entrance: Right, looking southward at the Wood River plant.



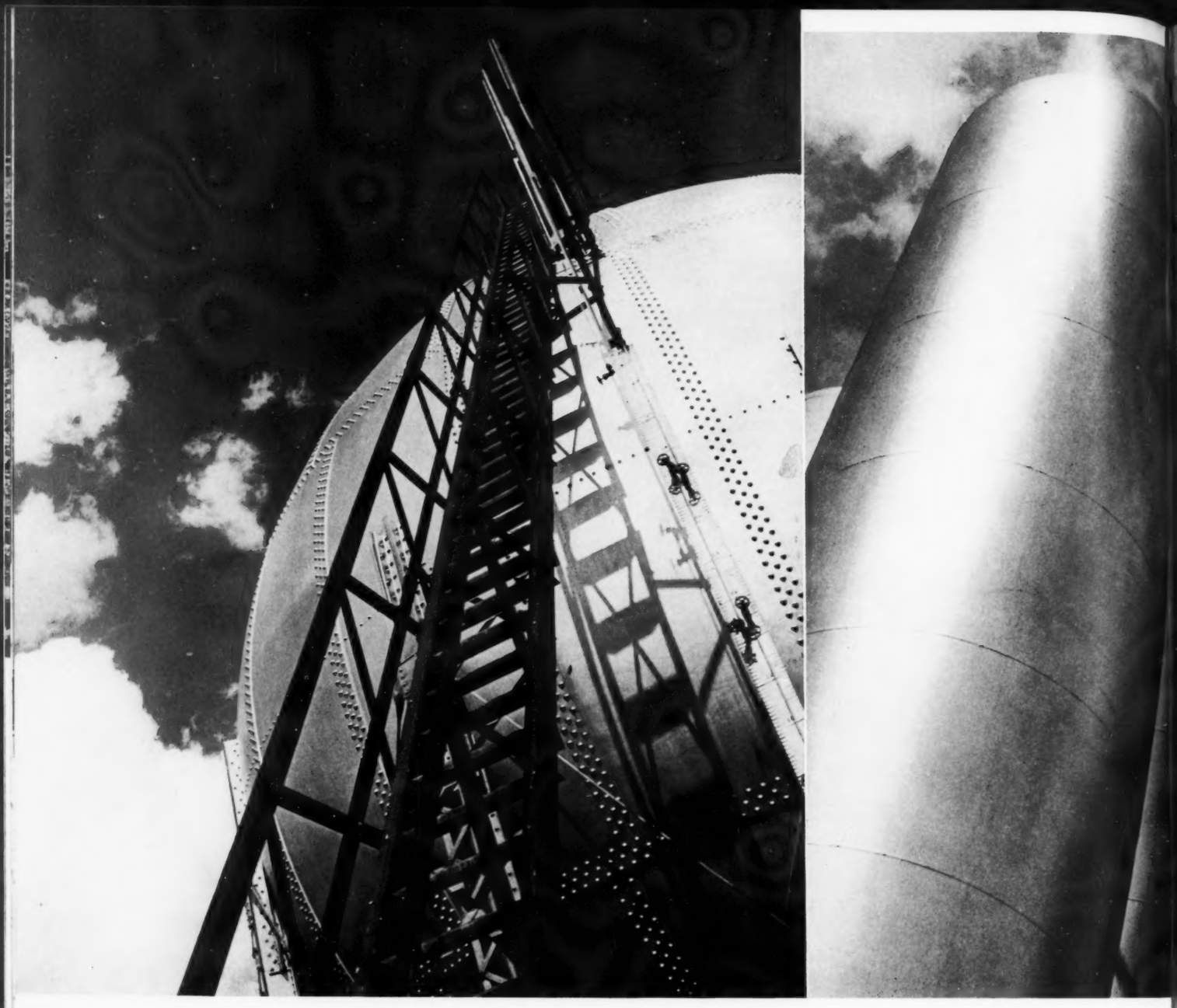
Left, below, a vista of gasoline treater rundown tanks with employees' cars in foreground: Above, a general view of the deasphalting and dewaxing plant.

The Wood River plant is one of seven refineries operated by the Shell Oil Company, Incorporated. The other six are at Martinez, Wilmington, Dominguez, and Coalinga, California; New Orleans, Louisiana; and Houston, Texas. The Houston refinery is of the same capacity as the Wood River plant so far as crude oil intake is concerned. Lubricants are manufactured at Martinez and Wood River where operations are more diversified, with the object of turning out a nearly complete line of petroleum products.

There is an eighth Shell refinery, located at East Chicago, but this one will discontinue operations when the finishing touches are given to Wood River's expansion program.

Shell's Wood River refinery first came into being as a small topping plant in 1918. Although not the earliest mid-western refinery of Roxana Petroleum Company, as the organization was then known, it was the first permanent plant. Prior to 1916 Roxana had been purely a production company and had developed especially productive acreage in Oklahoma at Drumright, Garber, Nowata, Healdton, and in other pools. In the latter year the company decided to expand into the refining phase of the industry, mainly due to the influence of the World War then in progress but also partly because of the uncertainties and variations in crude demand to which a production company is subjected.

In order to delay their entry into refining as little as possible, it was decided to build a temporary topping plant of 10,000 bbl. per day capacity at Cushing, Oklahoma, near the prolific Roxana production at Drumright, eight miles distant. This plant, which was completed in March, 1917, was intended for



operation only long enough to allow the selection of a refinery site more favorably located with regard to the more densely populated areas of the mid-west and to permit the construction of the permanent refinery and necessary pipeline connecting it with the crude supply.

The St. Louis region was speedily selected as the most promising location for the new plant and in April, 1917, construction was started at the 180 acre site in the center of a farming region near the east bank of the Mississippi about twenty miles from St. Louis. At the same time work was started on the 10-in. pipeline that was to bring crude from the fields over 500 miles away.

The Wood River refinery was originally designed to use two Trumble topping units each of 5,000-bbl. daily crude capacity, but before these were completed a third unit was added. These were examples of the very latest tube still design in contrast with the old type, low capacity shell stills commonly used in older oil refineries.

The infancy of the new Wood River refinery coincided with the first serious gasoline shortage. Not many years previously the gasoline fractions which had to be removed from the crude to make kerosene and heavier fuels had been to some extent a by-product. The war and the simultaneous rapid growth of the American automobile industry reversed this situation and refiners were making great efforts to increase the yield of gasoline over the percentage occurring naturally in the crude. These experiments followed the line of cracking or the breaking down of heavy fuel oil molecules into light gasoline fractions, a process long recognized in scientific laboratories but not previously applied in practice. One of the earliest and still one of the most widely used petroleum cracking processes is that developed by C. P. Dubbs. Much of the development work for this process was carried out at the Wood River refinery where the first commercial Dubbs unit was completed in 1921. Despite discouraging experiences, including fires and explosions during the early operations, the new cracking unit speedily demonstrated its worth, and before the end of 1922 six Dubbs plants were operating at Wood River.

From then on the Wood River refinery expanded in all phases of its operations. A total of eight Trumble type topping units was installed, two of which were utilized for rerunning treated pressure distillate. Installation of these topping units and later improvements in their operation increased the crude oil capacity to 45,000 bbl. per day. From six in 1922, the number of Dubbs cracking units grew to sixteen in 1929. These sixteen Dubbs units met requirements up to about 1935, when work was begun on a new and much larger unit, now known as "Dubbs No. 17." This was a move toward modernization in

Extreme left, above, Horton sphere for gasoline storage under pressure; above butane and propane storage tanks: Right, flame arrestor atop one of the smaller product tanks.

order to realize the many advantages of multiple coil cracking.

The East Chicago plant was processing about 30,000 bbl. per day of crude oil, drawing much of its supply from a Shell pipeline that passed Wood River's door. By 1938 it had become apparent that the East Chicago plant was obsolete in a commercial if not in a technological sense, and that real economies in overhead and operation could be effected by concentrating the work at Wood River. Provisions are being made to transport refined products instead of crude oil through the Wood River-East Chicago section of the pipeline. Another product line now serves Indian-

apolis and Western Ohio from the Wood River refinery.

The expansion program to put this idea into effect at Wood River began in the summer of 1939 and at the present writing (June) is very nearly complete. The program has included revamping and enlarging the crude topping section, the erection of a new large Dubbs cracking unit (Dubbs No. 18) complete with coking chambers, addition of a coking unit to Dubbs 17, a reforming unit, new absorption facilities, a C3 polymerization plant, an alkylation plant, and extensions to utilities. Extensions to lubricating oil manufacturing facilities are also under way. These additions provide for the rated intake of 75,000 bbl. per day of crude oil. The functioning of the entire rebuilt and enlarged plant is outlined on the accompanying simplified flow diagram on pages 56-57.

The Wood River refinery draws its supply of crude oil from three principal sources. About two-thirds of the total comes through a Shell pipeline from the West Texas area. About one-sixth is drawn from Mid-Continent sources (Kansas and Oklahoma mainly), and the remaining one-sixth from the Illinois area. These crudes offer a sufficient range of raw material for a full line of finished petroleum products. The total tank storage capacity for these crudes at the refinery is about 1,000,000 bbl., of which about 400,000 bbl. are assigned to mixed West Texas crudes, 150,000 to selected West Texas crudes (source of medium viscosity index lubes), 350,000 to Mid-Continent crudes, and 100,000 to Illinois crudes.

Shell's Wood River refinery has three large modern crude topping units. One, known as Topping II, has a capacity of 16,000 bbl. daily of lube-bearing Mid-Continent crudes from which most of the special boiling range naphthas are made. Topping III, with a capacity of 27,000 bbl. per day, operates variously on West Texas, non-lube Mid-Continent, Illinois, and West Texas lube crudes. Topping IV has a capacity of 32,000 bbl. per day and operates exclusively on West Texas crudes. These three new topping units (II, III, and IV) are of the same general pattern, except that Topping II has auxiliary towers and equipment for making special boiling range products. These units were designed by the Shell Oil Company, who purchased all material. The contractors handled erection only. Two of the old Trumble topping units having a combined capacity of 15,000 to 16,000 bbl. per day are being maintained intact as marginal units to be used for utility purposes. These topping units take off light straight run gasoline and furnish intermediates and residues for various purposes. The low end point straight run gasolines produced are delivered to a common stabilizer system.

In Topping II (see diagram) which has a rated intake of 16,000 bbl. per day and is the refinery's specialty unit, the overhead from the primary column goes through a stabilizing column where the butane and lighter components are taken off as the overhead, while the bottoms of the stabilizer, after appropriate treatment, are disposed of as light naphthas. The bottom product from the primary column of this unit goes to the secondary column where the overhead is naphtha. Side streams drawn from the proper levels through strippers yield kerosene, No. 3 fuel oil, and special gas oil. Bottoms from the secondary column are sent to the vacuum reducing still where gas oil is taken off as overhead and the residue goes to the lube department for the preparation of high viscosity index lubricating oils. The vacuum reducing still was designed by The Lummus Company and includes a vacuum tower equipped with so-called shower trays which design allows lower pressure drop than with normal bubble tray design for vacuum service.

The overhead from the secondary column is further processed in two naphtha columns, the first of which yields a special naphtha

Two striking night views of one of the country's most important refineries: on the left may be seen the solutizer sweetening plant; and on the right, the alkylation plant, highly important units in a plant of inestimable importance to present plans for mobilization of United States industry for national defense.

which may be used following suitable treatment as odorless base or light kerosene which is free from odor and thus suitable for use as a vehicle in household fly sprays and for other insecticidal purposes. In recent years the use of insecticidal sprays has greatly increased, and the resulting demand for a suitable base oil has assumed respectable proportions. Besides selling its odorless base to compounders, the Wood River refinery puts out its own line of sprays, including one which is widely known as "Shell-Tox." A special laboratory is provided for controlling and standardizing these products by means of the Peet-Grady test and other biological procedures.

Many other special boiling range naphthas are manufactured at this unit which are suitable for various purposes, such as thinners for varnish makers and painters (V. M. & P.), Benzo-Sol (a petroleum solvent).

Topping III, as previously mentioned, processes 27,000 bbl. per day of crudes. The primary column of this unit yields a low final boiling point straight run gasoline which is transferred to the debutanizing system. The bottoms pass to the secondary column. The overhead from the secondary column is straight run naphtha, the residue furnishing a raw material for cracking or for making medium viscosity index lubricating oils. Attached to this secondary column are two side strippers which yield side streams of kerosene or light fuel oil and heavier fuel oil. It may here be noted that the residue from Topping III that is destined for cracking is sent to intermediate storage, from which it is drawn to the cracking furnaces of the recently enlarged Dubbs 17.

Topping IV is of similar design to Topping III, with a rated capacity of 32,000 bbl. per day of West Texas crude. Its primary column takes off a low end point straight run gasoline, the secondary column gives an overhead of straight run naphtha, and a side stripper takes out a fuel oil cut. The hot residue from the secondary column passes directly to the cracking furnaces of Dubbs No. 18.

It will, of course, be understood that all these topping units are provided with conventional heaters, heat exchangers, condensers, pumps, control instruments, etc., such as are commonly to be found in all oil refineries, but which for the sake of simplicity are omitted from the diagrams.

The light straight run gasolines from topping units II, III, and IV are combined and delivered to a debutanizing column of the straight run gasoline stabilizing system where the C_4 and lighter hydrocarbons are removed from the top and delivered to other parts of the refinery for further processing. The stabilized light straight run gasoline is delivered to a solutizer treating plant which is described later.

The Wood River refinery now has two large Dubbs cracking units operating on reduced crudes or residue. The first to be built was Dubbs No. 17, which was put on stream in 1936 and enlarged in 1939 by addition of a second coking section. It replaced a number of smaller and less efficient old Dubbs units and made possible larger yields of higher quality products.

Dubbs 17 employs the principle of multiple coil selective cracking in which the light and heavy portions of the charging stock are separated by distillation and given thermal cracking treatments appropriate to their respective natures. This plant has two identical cracking sections, each with its own fractioning equipment.

As shown in the flow diagram, topped crude which has a temperature of about 100 deg. F. is taken from intermediate storage and sent to a cracked gasoline fractionating column where it is used as a quenching medium and is heated to about 740 deg. F. It then is charged to the Dubbs equiflux heavy oil cracking furnace. A side stream from the fractionating column enters a stripper from which a charging stock is taken for the Alcorn

light oil cracking furnace. The cracked vapors from the two furnaces enter the same reaction chamber on their way to the flash chamber and the lower part of the fractionating column.

The combined residues from the two flash chambers of Dubbs 17 enter a fractionating column on their way to the coking furnaces. The overhead is delivered to the cracked gasoline stabilizing system. After removal of cracked gas oil in a side stripper, the residue is divided between two quiflux coking furnaces and is delivered to a battery of six coking chambers. The final products from this cracking unit are gas, gasoline, cracked gas oil, and coke. When processing the normal charging stock, the yield of cracked gasoline from Dubbs 17 is about 60 percent. A cut of about 10 percent, mostly gas oil, is taken. The coke produced amounts to approximately 65 lbs. per barrel of charge, and the rest is accounted for by gas (propane and lighter).

The coke is removed from the coking chambers by a hydraulic arrangement which was developed by Shell engineers and has been amply described in the literature. Its convenience and economy have already assured it a place in other refineries in substitution for the previous cumbersome cable mechanism. The discharged coke is received directly into standard gauge railway cars which take it to a screening plant where it is graded. As is well known, petroleum coke is an excellent fuel and finds a ready market.

The latest cracking plant installed at Wood River is Dubbs 18 which was erected by Lummus. This unit provides the cracking capacity needed as a result of the increase in crude throughput. Construction of this plant was begun in the middle of 1939 and it is now in operation. In design and construction it differs in many respects from Dubbs 17 which was installed in 1936.

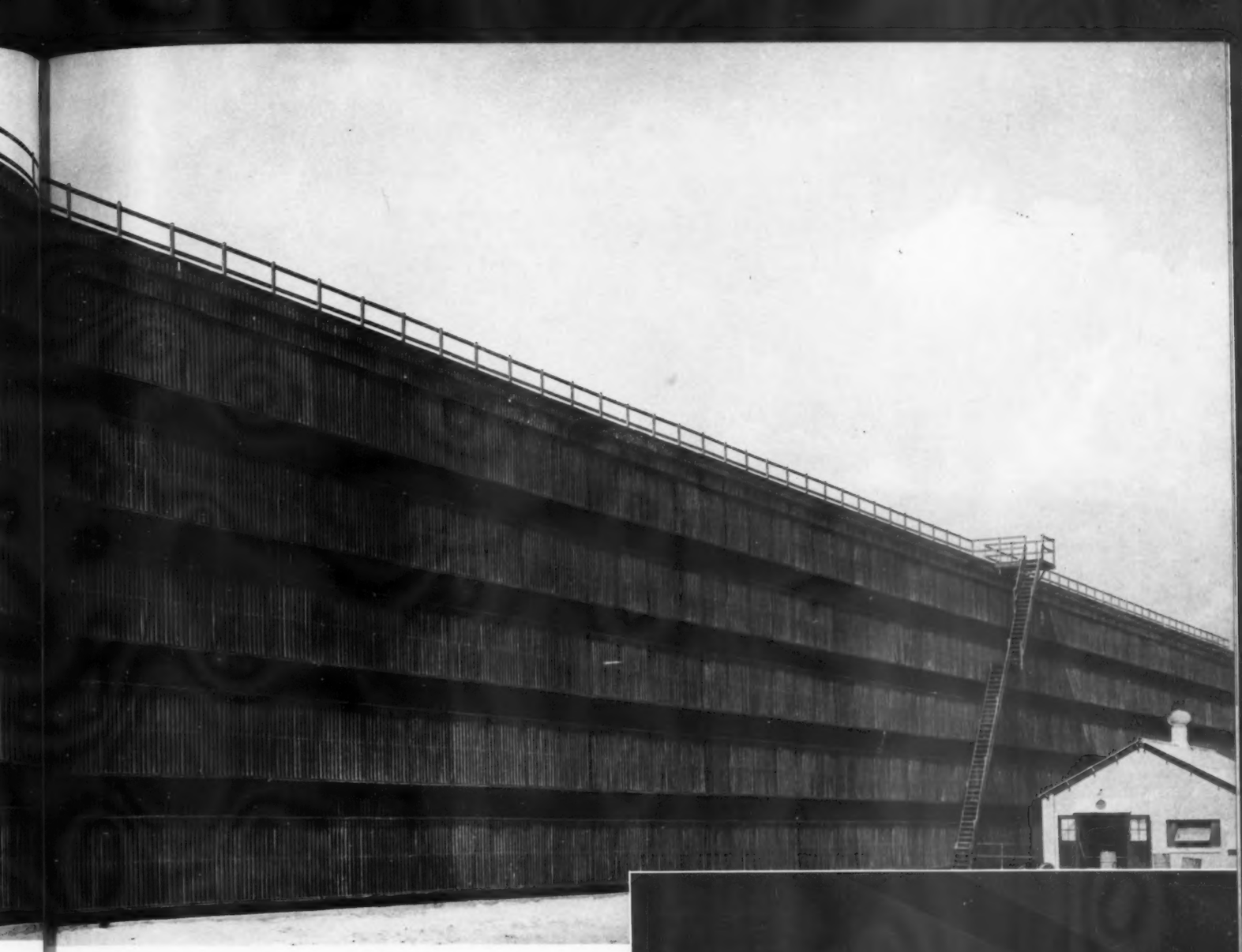
It was mentioned above that Dubbs 17 employs multiple coil selective cracking in which the light and heavy fractions of the charge are cracked in separate furnaces. In Dubbs 18 no such separation is made; the reduced crude issuing from Topping IV is sent to the cracking furnace direct. Another point of difference is that for Dubbs 17 the reduced crude is first sent to intermediate storage and reaches the cracking plant at a relatively low temperature. In contrast, Dubbs 18 is designed to perform the operation upon the hot reduced crude which is sent direct from the topping unit to the cracking plant with as little interruption as possible.

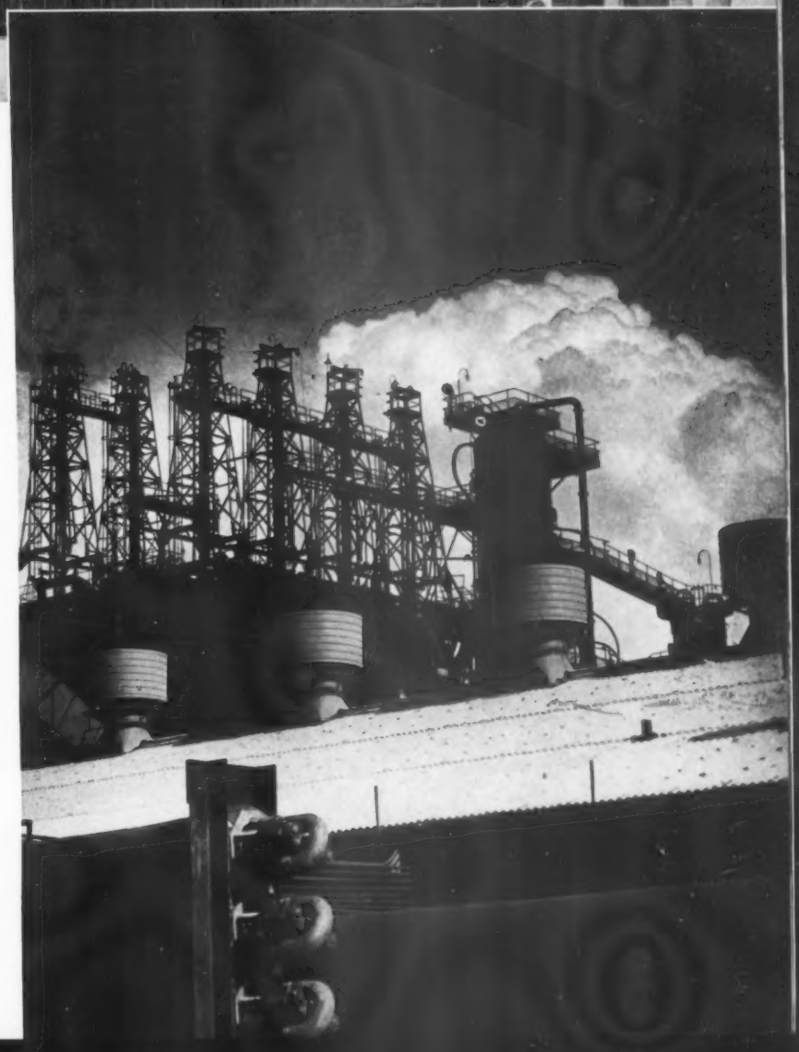
As indicated in the flow diagram, the hot reduced West Texas crude from Topping IV (about 18,000 bbl. per day) enters the equiflux cracking furnace of Dubbs 18. After passing through the reaction chamber, the cracked product enters the bottom of a high pressure fractionating column where unstabilized gasoline is taken off as overhead. The residue is further stripped in a low pressure fractionating column. The bottoms from the low-pressure fractionating column pass to the coking distillation fractionating column. A side stream is taken from this column to a stripper. The stripper overhead vapors are

returned to the fractionator while the bottoms pass on to a Lummus steam generator which is a feature of this plant. The overhead from the coking distillation fractionating column joins the other unstabilized cracked gasolines produced on this unit.

To continue, the residue from the coking distillation fractionating column is sent to the equiflux coking furnace where it is reduced to gasoline, gas oil, and coke. The battery of coking chambers consists of four vertical cells (there are six in Dubbs 17) each 13 by 50 ft., weighing approximately 100 tons each. For erecting them the Lummus crew used a stiff leg derrick with a 125-ft. boom capable of handling a load of 100 tons on a radius of 100 ft. The ease with which the big crane took these huge vessels from the railway cars and set them in place is still commented on by local engineers who witnessed the operation. The coke which accumulates in these chambers is removed by means of hydraulic decoking apparatus previously mentioned.

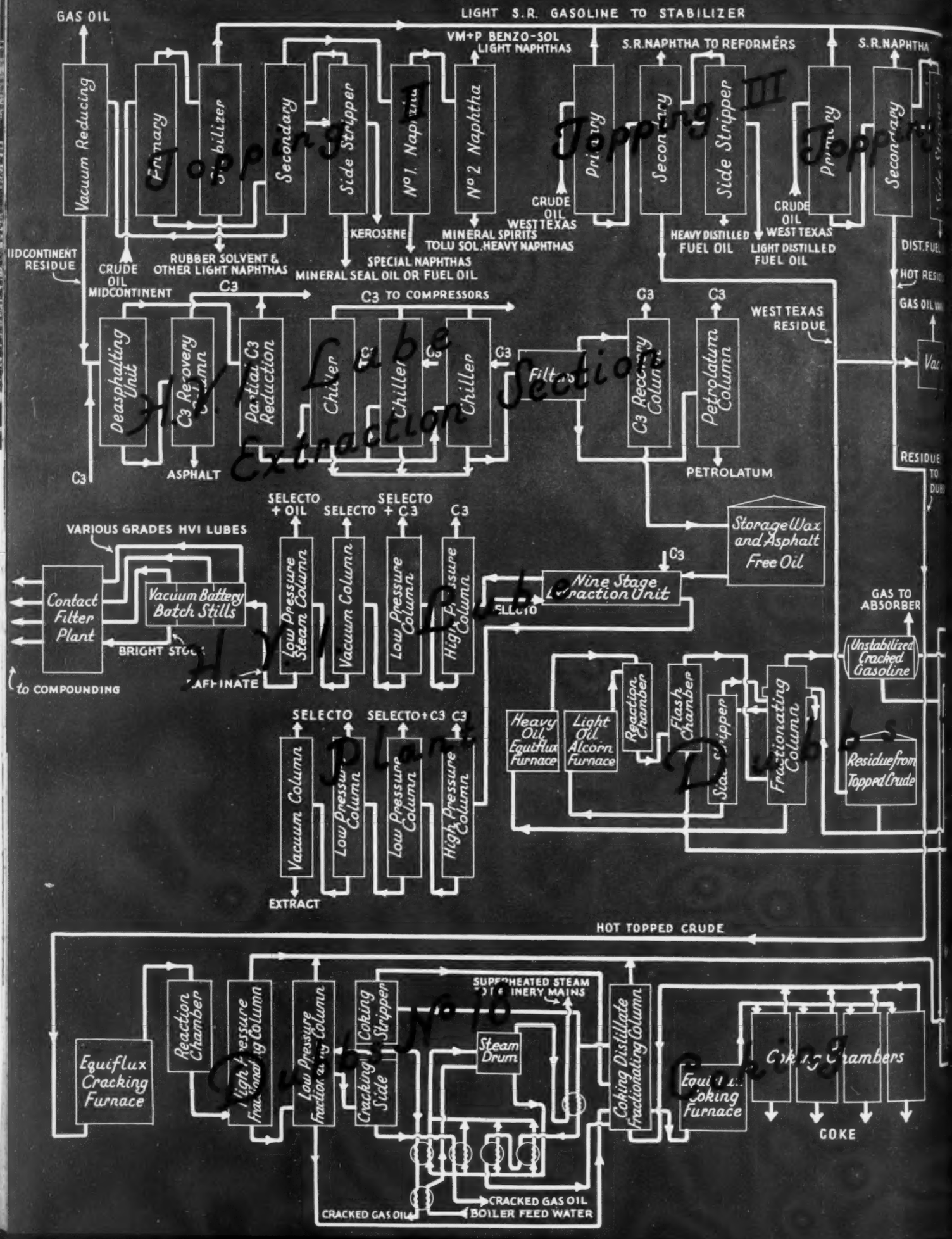
It was mentioned above that cracking plant Dubbs 18 operates on topped crude from Topping IV which is fed exclusively with West Texas crude that is somewhat high in sulfur, and it is perhaps unnecessary to say



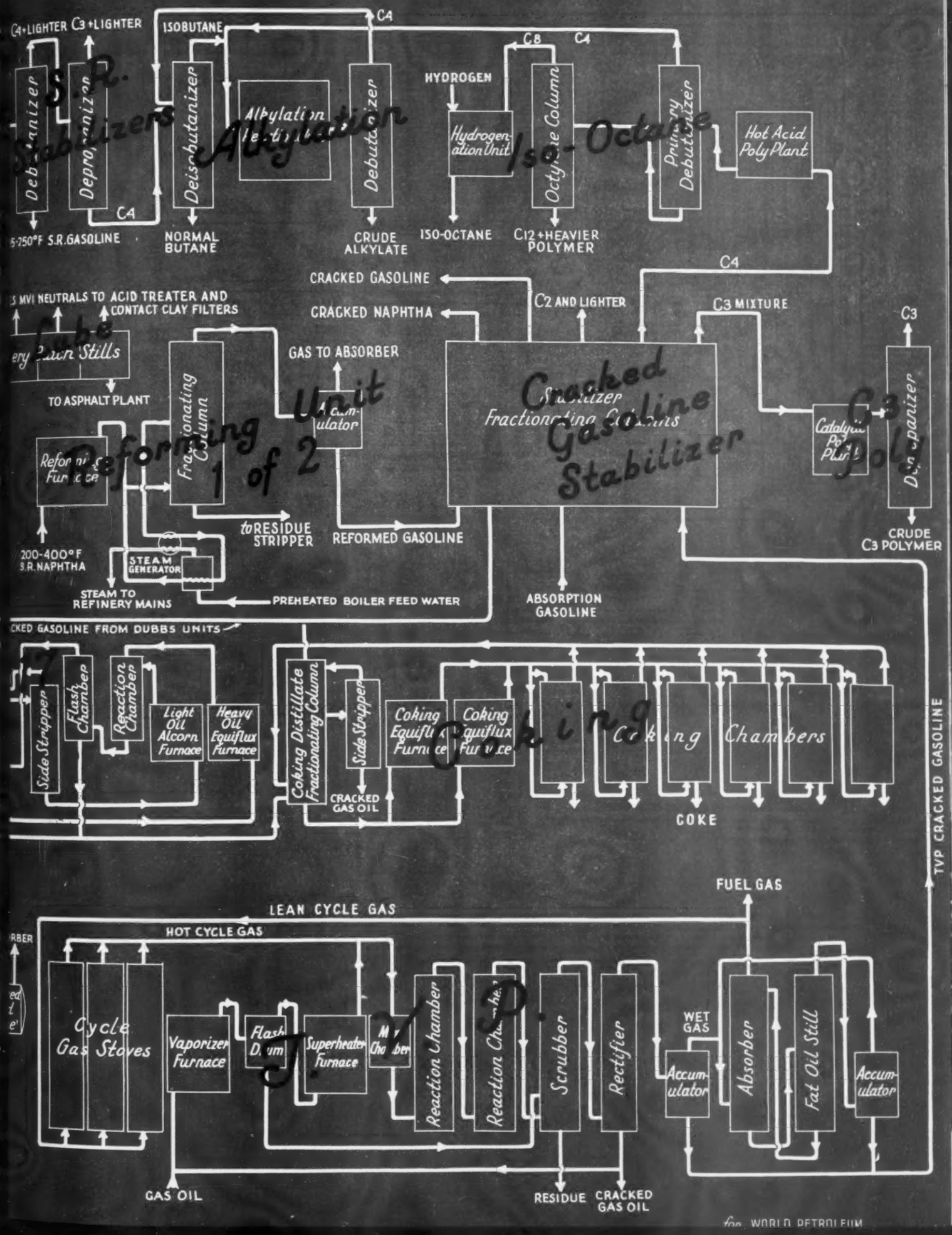


The Wood River refinery covers many acres on the left bank of the Mississippi River, has a total capacity of 75,000 bbl. of crude per day, and comprises a number of individual units. At the extreme left may be seen the chillers and filter surge tanks at the deasphalting and dewaxing plant; Directly above, the huge water cooling tower; and on the right Dubbs No. 17 hydraulic decoking towers seen over the pump house connected with the Dubbs No. 18 unit. On the following two pages a generalized flow diagram of the outstanding units of the whole Wood River plant is reproduced.

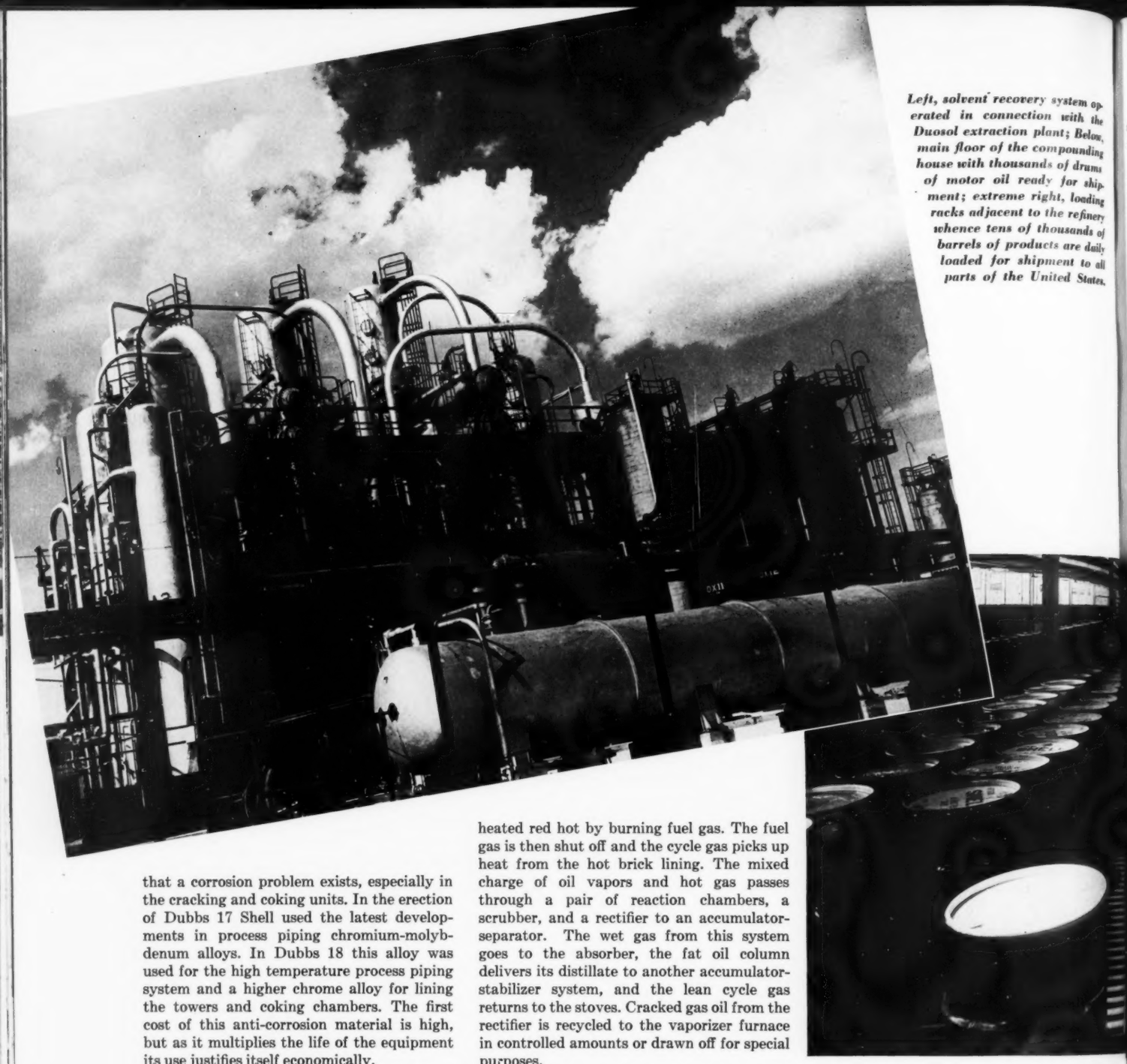
GENERALIZED FLOW DIAGRAM OF



SHELL WOOD RIVER REFINERY



for WORLD PETROLEUM



Left, solvent recovery system operated in connection with the Duosol extraction plant; Below, main floor of the compounding house with thousands of drums of motor oil ready for shipment; extreme right, loading racks adjacent to the refinery whence tens of thousands of barrels of products are daily loaded for shipment to all parts of the United States.

that a corrosion problem exists, especially in the cracking and coking units. In the erection of Dubbs 17 Shell used the latest developments in process piping chromium-molybdenum alloys. In Dubbs 18 this alloy was used for the high temperature process piping system and a higher chrome alloy for lining the towers and coking chambers. The first cost of this anti-corrosion material is high, but as it multiplies the life of the equipment its use justifies itself economically.

Another distinction of Shell's Wood River refinery is that it was the first to make commercial application of the true vapor phase (T. V. P.) cracking process. This unit processes gas oil and has a rated intake of 5,000 bbl. per day. The charge first passes through a vaporizer furnace in which practically complete vaporization is accomplished. The unvaporized portion of the charge is separated from the vapor in a flash drum. The vapor from the flash drum is superheated in a separate furnace and passes into a mix chamber where it is mingled with hot cycle gas which serves as a heat carrier. This heat is supplied by three alternating cycle gas stoves which are built and operated like the stoves of a blast furnace. These stoves are filled with refractory checker work bricks which are heated red hot by burning fuel gas. The fuel gas is then shut off and the cycle gas picks up heat from the hot brick lining. The mixed charge of oil vapors and hot gas passes through a pair of reaction chambers, a scrubber, and a rectifier to an accumulator-separator. The wet gas from this system goes to the absorber, the fat oil column delivers its distillate to another accumulator-stabilizer system, and the lean cycle gas returns to the stoves. Cracked gas oil from the rectifier is recycled to the vaporizer furnace in controlled amounts or drawn off for special purposes.

As was said above, the T. V. P. plant at the Wood River refinery was one of the first to employ this process commercially. More recent T. V. P. plants built elsewhere employ direct fired heating coils instead of stoves for conferring heat on the cycle gas. This pioneer T. V. P. plant is still earning its keep.

The refinery is also equipped with facilities for reforming naphthas. Dubbs 17 has a reforming section which, although it is a part of this plant, actually operates as an independent unit. The charge consisting of straight run naphtha passes through the reforming furnace and into a fractionating column, the bottom of which flow to a residue stripper. The overhead from the fractionating column goes to a stabilizer from which reformed gasoline is drawn and from which the top vapors yield a light cracked gasoline and a wet gas for the absorption system.

In addition to the reforming section of Dubbs 17 discussed above, the Wood River refinery has a large reforming unit termed "Dubbs 1" which was recently installed. This unit also charges straight run naphtha and has its own fractionator and residue stripping equipment. The reformed gasolines produced at this unit and the reforming-section of Dubbs 17 are stabilized in a common stabilizer. A side stream from the fractionating column of Dubbs 1 is passed through a steam generating unit. The relatively cool side stream leaving the steam generator is returned as a quench to the hot vapors from the reforming furnace. The

steam delivered by this reforming unit is approximately 16,000 lbs. an hour.

The cracked and reformed gasoline stabilizing system receives the combined overheads from the Dubbs cracking units, the two reforming units, the true vapor phase cracking unit, and the gasoline from the absorption plant. These stocks are separated in a series of efficient fractionating columns into C_2 and lighter, C_3, C_4 low end point gasoline and cracked naphtha. The C_4 fraction is transferred to the hot acid polymerization plant and the light gasoline passes to the solutizer treater.

The C_3 product is composed of propane and propylene. The propane-propylene blend from which hydrogen sulfide and low molecular weight mercaptans have been removed enters a Shell catalytic polymerization plant. In this plant the propylene is polymerized to yield a high octane polymer gasoline. A portion of the residual propane from this unit is delivered to the lubricating oil department where the Duo-Sol extraction process is practiced. The excess of propane not required by the Duo-Sol process is condensed and purified for sale as liquid gas under the name of "Shellane" or consumed as fuel gas.

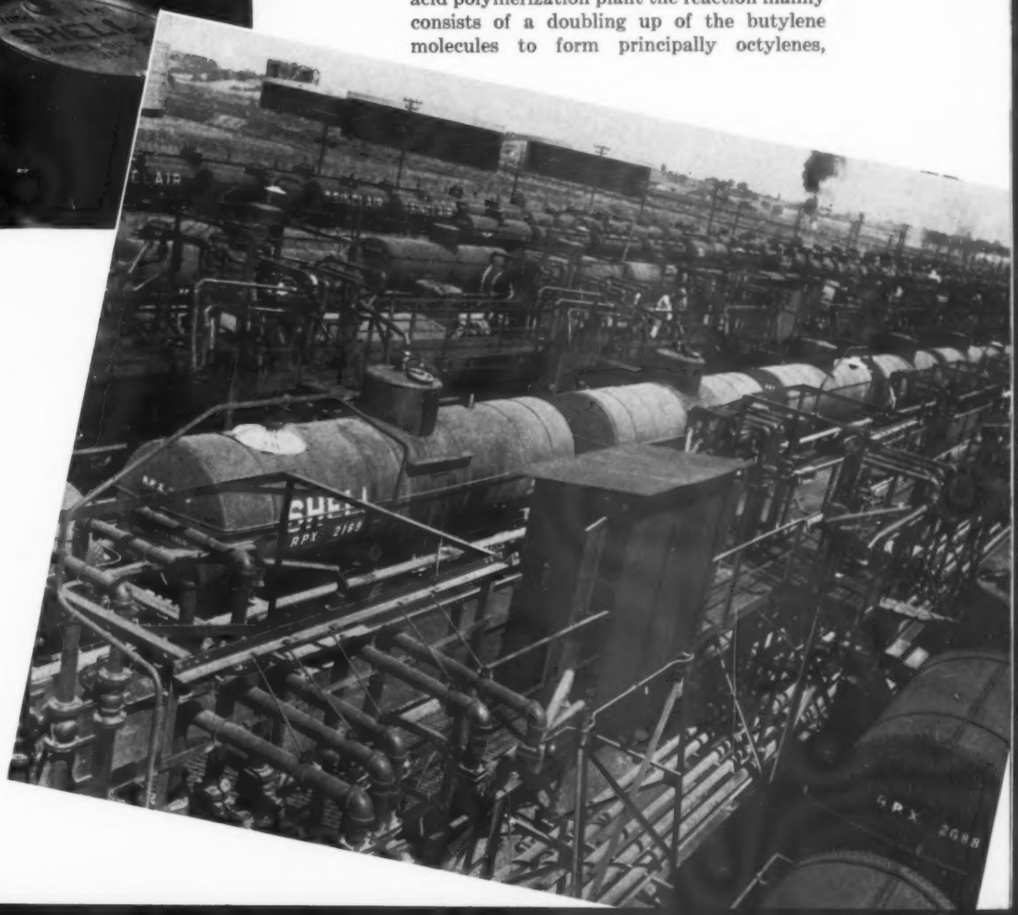
For removing hydrogen sulfide from the C_3 polymerization plant charge present refinery expansion plans include a potassium phosphate plant. This process which was developed by Shell and is already in plant scale operation at other refineries scrubs the gas with an aqueous solution of tri-potassium phosphate in an absorption tower to remove the hydrogen sulfide. The phosphate solution is then freed of hydrogen sulfide with steam in another tower and returned to the absorption tower. The phosphate solution may be used almost indefinitely.

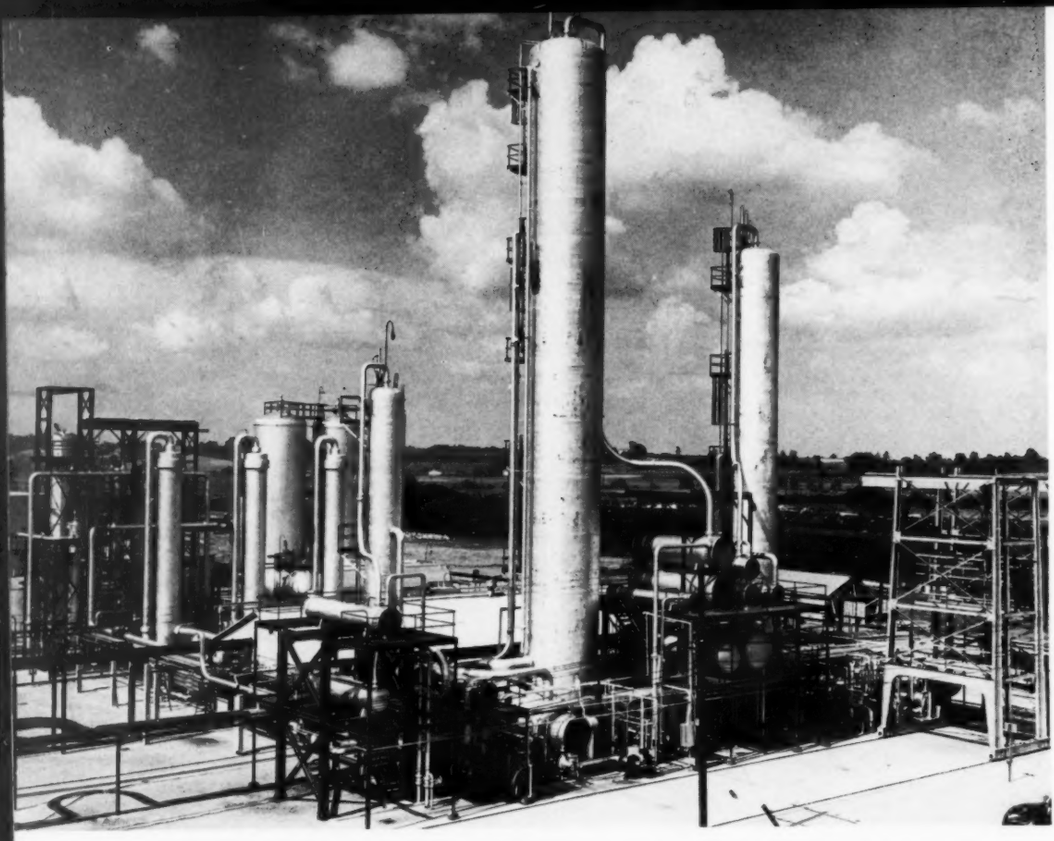
It was previously mentioned that the light straight run gasoline productions of the various topping units are combined and enter a debutanizer where the C_4 and lighter constituents are removed. This overhead material is further fractionated to yield iso-butane, a raw material for the alkylation unit. The iso-butane that is obtained from the de-iso-butanizer is combined with a cracked C_4 fraction obtained from the cracked gasoline stabilizing system to yield a high octane number alkylate.

The alkylation plant is similar to a number of others now in existence or contemplated in various domestic and foreign oil refineries. The process was developed jointly by Shell, Anglo-Iranian, Humble, Standard (N. J.), and Texas. The underlying principles of the process have been explained in various publications, notably in a paper, "High-Octane Aviation Fuel by the Sulfuric-Acid Alkylation Process," presented by S. H. McAllister at the Chicago meeting (November, 1939) of the American Petroleum Institute. Briefly, the process consists of contacting the C_4 olefins obtained from the cracked gasoline stabilizing system with iso-butane in the presence of strong sulfuric acid at low temperatures. Under the influence of the acid the iso-butane combines with the C_4 olefins. The product is a mixture of saturated branch-chained hydrocarbons, substantially octanes. The crude alkylate requires only fractionation to bring it within requirement for aviation gasoline. The process portion of this alkylation unit was fabricated by C. F. Braun and Company. The refrigerating system required for controlling the heat of reaction was designed, fabricated, and erected by Worthington. The Fluor Corporation were general contractors on erection.

The alkylation process mentioned above is a process for making a product (A. S. T. M. octane number 92-93) which is an excellent high octane number aviation gasoline, the principal constituents of which are iso-octanes. Before the advent of this new process, the Wood River refinery already had an iso-octane plant. In fact, this refinery has the distinction of being one of the first to put up a plant for the commercial manufacturer of iso-octane, and it is thus entitled to be regarded as giving a major impetus to the modern aviation gasoline industry.

As indicated on the diagram, the first unit of the Wood River iso-octane plant is a hot acid polymerization plant where the C_4 hydrocarbons from the debutanizing column of the cracked gasoline stabilizing system after suitable treatment are contacted with hot sulfuric acid. The iso-octane plant and its neighbor, the alkylation plant, thus work on practically the same olefinic raw material. But whereas in the alkylation plant the saturated hydrocarbons (typified by iso-butane) join up with the unsaturated hydrocarbons (typified by butylene) to produce a product which is largely iso-octane, in the hot acid polymerization plant the reaction mainly consists of a doubling up of the butylene molecules to form principally octylenes,





General view of the alkylation plant, one of the units constructed in the recent modernization program.

unsaturated C_8 compounds. The remainder of the iso-octane manufacturing process then consists in removing the unaffected C_4 compounds (which still contain some butylene) in a debutanizer column. Following the debutanizer is an octylene column where octylenes (unsaturated C_8) are taken off overhead and from the bottom are extracted the C_{12} and heavier hydrocarbons which are transferred to motor gasoline. The octylenes are passed to the hydrogenation unit where they are catalytically converted into iso-octane (A. S. T. M. octane number 97). The necessary hydrogen for the hydrogenation unit is obtained by dissociating ammonia gas (NH_3) in a special electric furnace manufactured by General Electric.

The Wood River refinery is abundantly equipped with facilities for treating its wide range of products to high quality standards. Continuous type treaters and batch agitators are extensively used for treating gasolines and intermediate products with acid, caustic soda, clay and other chemicals to remove undesirable constituents. Three different processes are used for sweetening sour gasolines, naphthas, and fuel oils. These include the solutizer process and U. O. P. copper sweetening.

A short discussion of the solutizer process will be of interest. This process employs a principle worked out by Shell Development Company, Emeryville, California, and developed on a commercial scale at the Wood River refinery. It not only replaces the usual doctor treatment for sweetening sour gasoline but has many other advantages mentioned later. As is well known, the ordinary doctor treatment converts mercaptans to disulfides and polysulfides which remain in the gasoline and are objectionable for various reasons.

The solutizer process has been previously described in the literature [see articles by Yabroff and Border, Refiner, 18 (5), 171-6, 203 (1939), and Yabroff and Nixon, Refiner, 19 (3), 74-76 (1940)]. In outline it is based on the equilibrium reactions indicated by this equation:

$$\underset{\text{oil}}{RSH} \rightleftharpoons \underset{\text{water}}{RSH} \rightleftharpoons KSR$$

In words this equation says that when a mercaptan contained in gasoline (R S H, oil) is shaken with a water solution of caustic potash, a part of the mercaptan is dissolved in the water (R S H, water) where it can be made to combine with caustic potash to form a compound K S R which can be hydrolyzed and the mercaptan removed from the system. The difficulty in utilizing this reaction commercially is that the solubility of the mercaptan in water is very small and the rate of conversion into the potash-mercaptan compound (K S R) is too slow for commercial exigencies. The trick is to increase the solubility of the mercaptan in the alkaline-potash solution by adding to it some potassium iso-butyrate, which brings the solubility of the higher mercaptans within technological requirements. The manipulative operation then becomes a matter of contacting the sour gasoline with a caustic potash-potassium iso-butyrate solution in countercurrent in the cold. The alkaline solution is then regenerated with steam, expelling the mercaptan compounds. To prevent an accumulation of sulfides in the alkaline solution, the sour gasoline is first washed with caustic soda which also removes traces of other acidic compounds which might otherwise eventually foul the solutizer solution.

The solutizer process is regarded by Shell as an extremely valuable improvement over the classic doctor treatment. As applied at Wood River, the solutizer process has exhibited the following important advantages:

1. The sulfur content of the gasoline is reduced.
2. The octane number of the gasoline is increased slightly by the treatment.
3. The susceptibility of the gasoline to tetraethyl lead is notably improved.
4. Gasoline losses are decreased as compared with doctor treatment.
5. The gum properties of the gasoline are improved.
6. Operating costs are less than for conventional doctor treatment.

At Wood River the stabilized light straight run and cracked gasolines from the topping and cracking departments, respectively, are treated by this process. The average mercap-

Safety is an important consideration at the Wood River plant and accidents among the 3,000 employees are held to a minimum; the ambulance below is on constant duty at the refinery.

tan sulfur content of the sour gasoline is on the order of 0.09 to 0.12 percent which is reduced by the solutizer treatment to 0.0001 to 0.0002 percent which is well within the limits required for doctor sweetness. The capacity of the new solutizer plant is 12,000 bbl. per day.

A point of further interest in the solutizer process is that it permits the isolation of the mercaptans in quantity and thus makes them available for industrial purposes. Just what place they will find in chemical industry is not fully known but the matter is said to have attracted the attention of rubber manufacturers and various chemical interests.

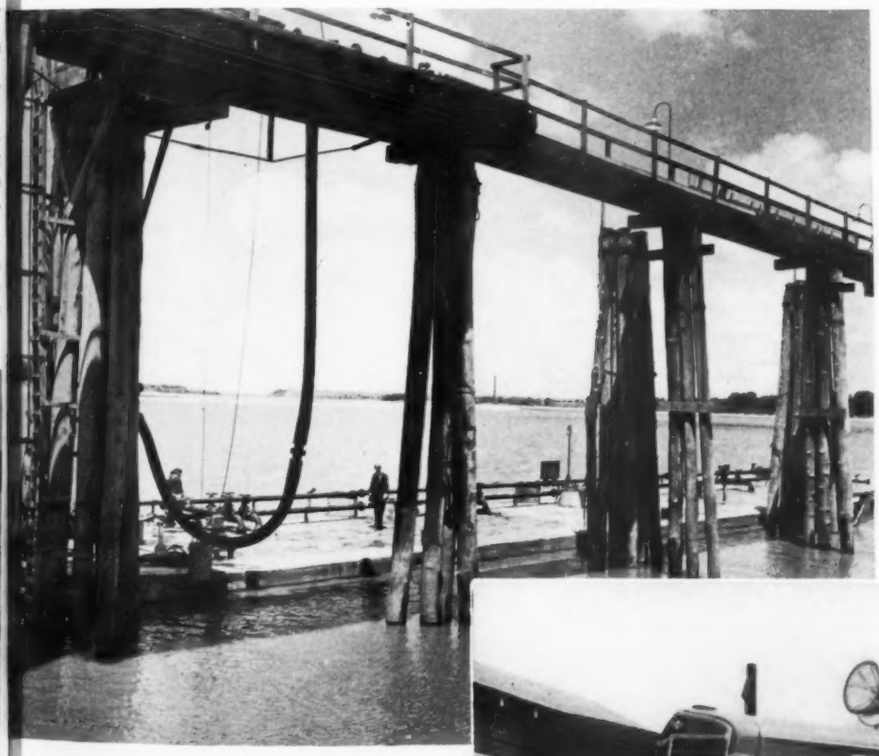
Shell's Wood River refinery produces two general types of lubricating oils, viz., medium viscosity index (M. V. I.) oils and high viscosity index (H. V. I.) oils. The former are obtained from the residue of selected West Texas crude oil processed on Topping III. The equipment consists of a battery of vacuum shell stills in which the residue is fractionated into five grades of neutral distillates and asphalt bottoms. The various grades of neutral distillates produced are sent to the agitators or the Sharples plant for treatment with acid followed by either a caustic neutralization step or contact filtered with clay as the case may require. The asphalt bottoms are delivered to the asphalt plant.

The H. V. I. lubricants are made from Mid-Continent residue from Topping II. The residue after being reduced to the proper viscosity by removal of gas oil fractions in a Lummus vacuum reducing unit is successively deasphalted, dewaxed, solvent extracted, fractionated, and clay filtered.

A general view of Topping Plant No. 2 which can readily be placed from a glance at the generalized flow diagram on pages 56-57.

The deasphalting and dewaxing operations are carried out in the D & D Plant. The reduced Mid-Continent residue is mixed with liquid propane and then passed into the asphalt settling tank at temperatures of about 110-120 deg. F., where the asphalt is precipitated and drawn off. The asphalt which contains some propane, is pumped to a still, where the propane is removed and recovered. The deasphalted oil-propane solution goes through a separator, where a portion of the propane is removed in order to obtain the desired oil-propane ratio required in the dewaxing step which follows.

Dewaxing is also carried out in propane solution. The deasphalted oil-propane solution is chilled in vertical vessels to temperatures on the order of –45 deg. F. The chilling effect is accomplished by evaporating the liquid propane, enough cold propane being added to maintain the proper oil-propane ratio. The slurry of oil, propane, and precipitated wax is pumped to continuous rotary Oliver filters,



Barge loading rack in the river: Wood River products travel by pipeline, rail, water and truck. Right, a modern emergency truck, part of the elaborate defenses against fire and accidents.

where the wax or petrolatum is removed. The filtrate or dewaxed oil is passed through a still in which the propane is removed and recovered, leaving a deasphalted and dewaxed (D & D) oil. Propane is also recovered from the petrolatum removed from the filter.

The Duo-Sol process is employed to solvent extract the D & D oil. In this process two solvents, Selecto (a mixture of cresylic acids and phenol) and propane are used in countercurrent flow through a nine stage extraction unit. The raffinate solution and extract solution obtained from this unit are passed through a solvent recovery unit where the propane and Selecto are recovered for re-use.

The solvent-free raffinate is fractionated, yielding several grades of neutrals and a bottoms of bright stock. All of these stocks are contact filtered as a final finishing treatment.

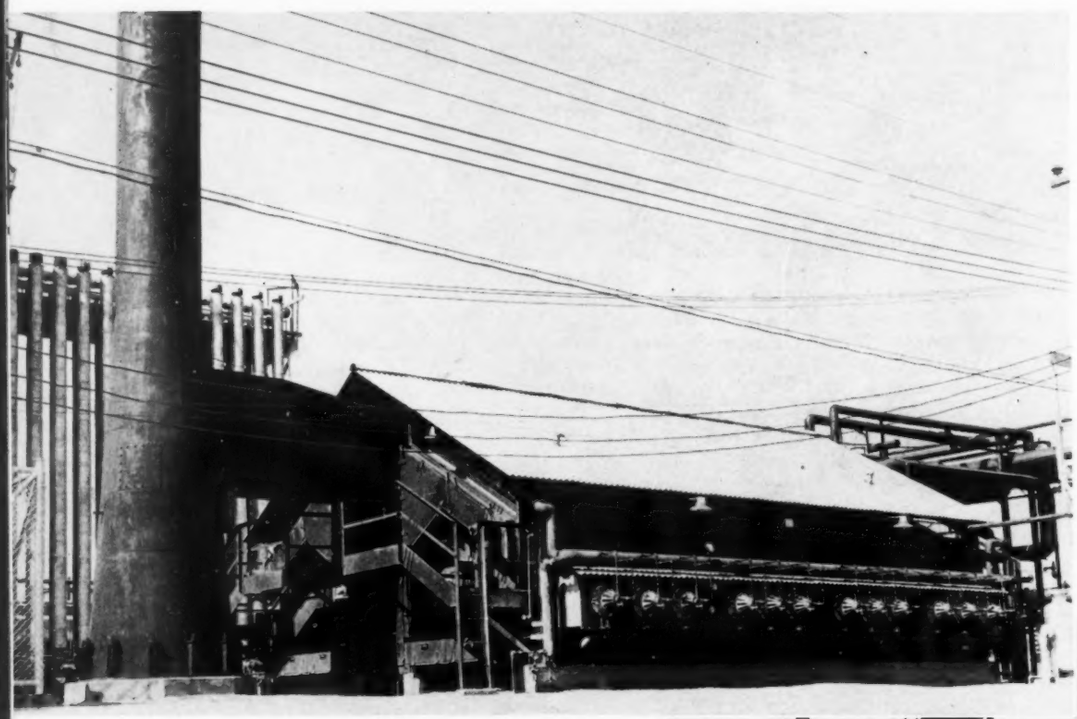
The finished, filtered H. V. I. base stocks are turned over to the blending and compounding department where a full line of lubricants, aviation, automotive, and industrial are made, prominent among which is Golden Shell motor oil.

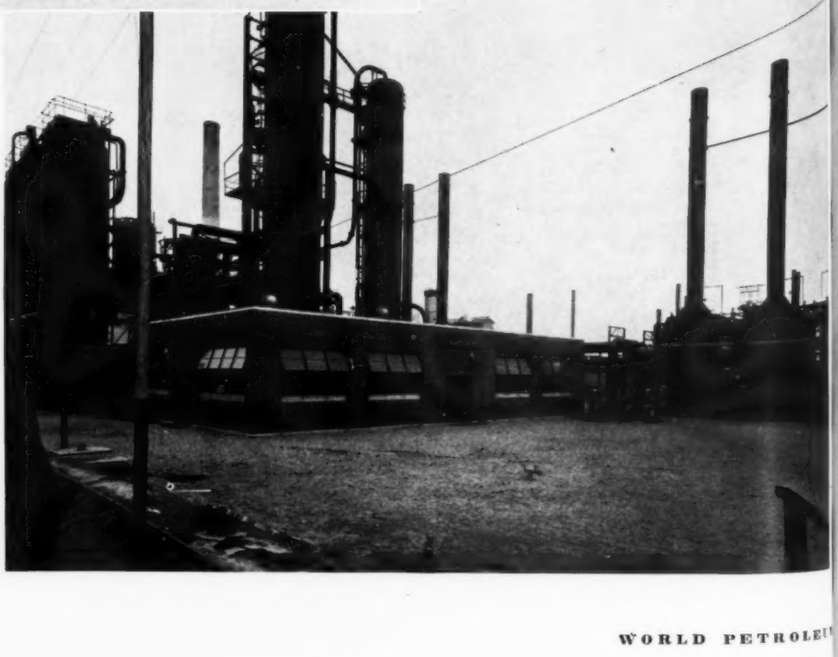
There are two boiler houses at the refinery which are fired with gas, fuel oil, and solid fuels such as powered petroleum coke. The combined normal or rated capacity of these two plants is approximately 15,000 h. p., but the exigencies of operation have required on occasion that all steam raising facilities be driven at peak rate of about 25,000 h. p. The load on the boiler houses is lightened to some extent by utilization of hot oil streams from the operating units for preheating boiler feed water and generating steam in steam generating units located at the operating units. A hot oil stream from the fractionators of Dubbs 17 is used to preheat boiler feed water at boiler house No. 2. The idea is carried out on a more extensive scale at Dubbs 18 where a Lummus steam generating unit has been installed. In this unit cold boiler feed water is heated and converted to steam, and the steam is superheated by hot cracked gas oil streams from the fractionator and side strippers of this cracking unit. The steam produced is introduced into the refinery steam mains. The capacity of this steam generating unit is 24,000 lbs. of steam per hour which is delivered with 100 deg. of superheat using the excess heat supplied by an intake of 18,000 bbl. of reduced crude per day. As previously mentioned, Dubbs No. 1, a naphtha reforming unit, is also equipped with a steam generating unit.

The benefits of this type of heat recovery system are not confined to the value of the superheated steam added to the refinery mains. The hot oil streams which now give up their heat in the steam generating plant would otherwise have to be cooled with water. The refinery is adequately equipped with cooling towers. The hot water from the condensers and coolers of the operating units is cooled in these towers and returned for further cooling purposes.

The water supply is obtained from 16 old wells and seven new 125-ft. wells that were spaced to provide the most satisfactory water supply. The average flow of the new wells is 600 gal. per minute which is delivered to the cooling water system through a 20-in. discharge header. The cooling water and boiler feed water are softened by conventional soda-lime processes.

Shell's Wood River refinery is equipped with a thoroughly modern system of handling and treating waste chemicals and waste water to prevent pollutive substances from entering the Mississippi River. This system has been extended appreciably in connection with the refinery expansion program. Additions have included the installation of a large new type separator for removing oil and sediment from the refinery waste water origi-





Furnace at the alkylation plant above; and right, a general view of Topping plant No. 4 which may be seen diagramatically on pages 56-57.

Wood River's extensive tank farm is shown partially in the photograph above taken from the top of the butane and propane storage tanks shown on page 51. Below, right, fractionating columns and reaction chamber of the Dubbs Unit No. 18.

ating in the cracking area. This separator was designed by the Refinery Waste Disposal Committee of the American Petroleum Institute.

The average number of employees at this refinery during recent months has been approximately 3,000, not including a large number employed by construction contracting firms. The company's accident and sickness insurance plan provides benefits to injured or disabled employees for a maximum period of 52 weeks, besides group life insurance. Much attention is directed to safety. To keep the minds of everyone alive to this highly important matter, each department is rated according to the "total running number of days worked without a disabling accident" it can show, and some of the departments have the satisfaction of posting on the doors of their headquarters a continuing record of several thousands of days.

Besides laboratory facilities for stringent chemical control of all refinery processes and products, the Wood River plant has a research laboratory which is one of three maintained by the Shell. The work of the Wood River research laboratory is about equally divided between chemical and process research and motor research, the latter largely in cooperation with other similar institutions. A large amount of work has been done in connection with the development of the C. F. R. motor method and more recently upon a method for evaluating high octane number aviation gasolines.

A main function of chemical research as distinct from plant control in the oil industry is the search for more efficient fuels suitable for internal combustion engines. As mentioned before, Wood River was one of the first refineries to produce iso-octane commercially for aviation purposes. There are indications that even this valuable material may lose some of its importance by the appearance of new substances that have still higher anti-knock qualities, especially as supercharging attains a more advanced development.

Petroleum Synthesis Can Supply Rubber in NATIONAL EMERGENCY

By Jay Farquar

One of America's Strategic Raw Material Problems Has Been Solved in the Labratories of An International Oil Company—Before Present Inventories Could be Exhausted Jersey Standard is Capable of Completing Facilities Adequate to Supply Synthetically Total U. S. Rubber Demand.

Polymerization of butadiene and acrilo-nitrile yields a milky viscid fluid similar to vegetable rubber latex (left); addition of a coagulant precipitates the pure Buna from its state of suspension (center and right), the size of the particles varying somewhat with the nature of the coagulant. Right, the crude Perbunan is readily separated from water and dried for mastication in the rubber mill.

BECAUSE of the inherent association with modern mechanized warfare, raw materials have become more and more involved in strategy and are a recognized constituent of national military power, so that along with the older types of armament competition we have a competitive raw materials race. This has been the foundation of the long struggle of fascist countries for economic autarchy in such raw materials as oil.

The United States is probably better off with respect to such raw materials than any other nation, but even so, there are a number of links missing from our national defense chain. One of the most important of these has been the lack of domestic supplies of rubber, but all that has ever been accomplished by way of surmounting this weakness has been the stimulation of methods for recovery of used rubber and the accumulation of limited stocks in case of emergency. Vast sums have been expended in research by Firestone, Edison and others, searching for an indigenous plant which would yield an appreciable quantity of latex, but without noticeable success.

Nevertheless, the United States, consumer of more than 60 percent of the world's rubber supply, is dependent for practically all of this upon the British and Netherland colonies in Ceylon and the East Indies. The involvement of both of these countries in the European War has cast the shadow of possible invasion by unfriendly powers over these islands, and indirectly threatens America's most important source of crude rubber supply.

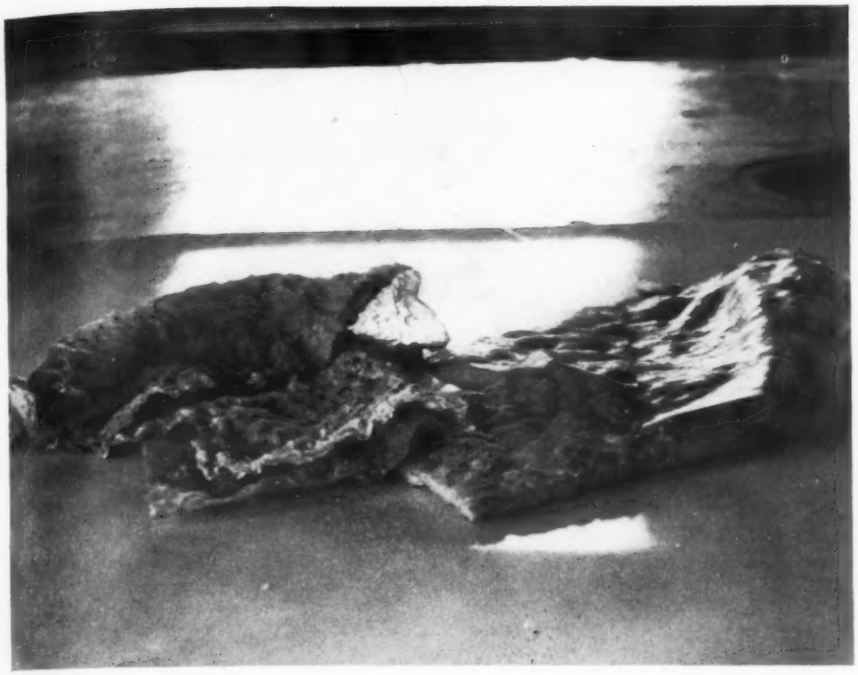
Anticipating the possible cutting off of such imports, the United States and Great Britain concluded a cotton-rubber barter deal some time back in which the nations agreed to swap these vital raw materials, and the rubber has been coming to the United States in small shipments for about six or seven months at time of writing. Consequently, some 10,000 tons of crude rubber already have been stored by the government at the U. S. Army base in Brooklyn and it is planned eventually to increase the amount of rubber stored there to a month's supply.

American consumption of crude rubber amounts to about 50,000 tons monthly; to meet this demand there is about three months' consumption in storage, another two months supply afloat to the United States, and about ten days' supply from reclamation of used rubber. It is apparent from this that there is available about five to six months' normal rubber demands, but it is a moot point as to how long adequate quantities can be brought into the country. Shippers in the East Indies have experienced increasing difficulty in booking cargo space for shipment of crude rubber due to withdrawal of vessels from those trade routes, and it is possible that the freight situation may grow progressively worse.

Until recently such a situation would have boded ill for the United States, but a recapitulation shows that this country no longer has anything to fear by way of a rubber shortage, because within the time it would take to consume available supplies of the natural product it would be possible to rush into completion sufficient industrial plants for the production of artificial rubber superior in most respects to the natural product. President Roosevelt has asked for $1,000,000 to encourage the cultivation of natural rubber in Latin America, but because it takes many years for the rubber tree to reach maturity such re-development could not be accomplished in time to meet an emergency such as extension of the field of combat to Pacific waters.

Nearly a decade of operation of processes for the manufacture of Neoprene and Thiokol has resulted in a combined output of about 1,750 tons per annum, equal to about 0.3 percent of the domestic consumption. By the end of 1940 output is expected to be at the rate of perhaps 4,000 tons yearly as a result of the installations now under construction by the oil industry.

During the past ten years there has been another process under development in the United States, one which already supplies 75 percent of the consumption in Germany. Known as Buna, the Standard Oil Company of New Jersey had co-operated with I. G. Farbenindustrie G.m.b.H. in research and has acquired the sole rights to its production in this country. In the past, small quantities of Buna have been imported to the American market from Germany with great success in use, and now two plants are being erected which will employ this process (one by Standard Oil and one by Firestone Tire and Rubber Co. under license from the oil com-



In the form of pure gum crepe the Perbunan is apparently the same as vegetable rubber at that stage except for the slightly paler color.

pany). Whereas the I. G. F. employs coal as a raw material, these concerns will employ petroleum, of which America has vast resources and which is far more suitable for low cost production.

Official announcement of this development was made in February, 1940, and detailed information regarding this product will be given later on in this article.

However, early in June of this year, during the company's annual meeting, W. S. Farish, president of Standard Oil, announced a new and additional source of synthetic rubber, a companion to Buna but cheaper and having somewhat different characteristics. This, he called Butyl rubber.

From the foregoing, it can be seen that in an emergency the United States has enough rubber supplies for more than five months, and should consumption be restricted to make them last longer it would be possible to rush into construction and completion enough Buna and Butyl polymerization units to supply the country with its normal consumption of 560,000 tons a year. Such construction (costs of Buna plants are given later) would involve an expenditure of perhaps $100,000,000 or more, but this would be a modest sum in comparison with the part that it would play in the country's national defense schemes.

Apart from Mr. Farish's remarks, little information is available regarding Butyl rubber, but the company is not quite so reticent regarding the commercially more advanced Buna product.

German use of Buna is already half her total consumption, and plants due for completion this year are expected to increase her production to three-quarters of her normal requirements. This rapid development was the result of a heavy protective tariff, but development in the United States will be without the benefit of such indirect subsidy. Standard Oil Company of New Jersey has developed the process, using petroleum as raw material instead of coal, to the point where Perbunan (Buna-N) may be sold in direct competition with natural rubber because of its many superior qualifications.

Figure 1: Swelling of Perbunan in comparison with rubber, 30 percent, P-33 stocks.

The first plant is being constructed by the company at its Baton Rouge refinery, and will have a daily output of five tons. Construction cost is expected to be between $1,000,000 and $1,250,000, and the unit is to be in operation by the end of 1940.

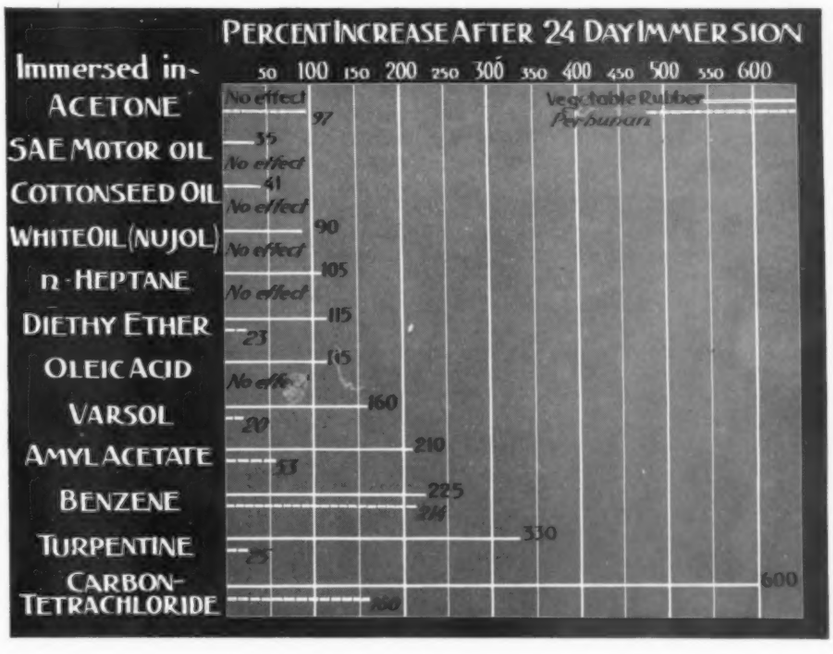
A small demand for Buna has already been established in the United States, formerly met by imports from Germany, and additional plants are to be constructed as occasion warrants. Construction cost of a plant capable of duplicating the output of all existing mineral rubber plants in the country would be between $5,000,000 and $10,000,000. Development is planned on a basis of gradual expansion—unless an emergency requires a speed-up of the program.

Output of the Baton Rouge and subsequent Buna plants is to be released through regular commercial channels.

Some of the rubber manufacturing interests who have followed German developments are considering the feasibility of purchasing the raw materials and processing them at their own factories, rather than to buy the crude Perbunan from the oil company. This is still possible inasmuch as the conversion unit is relatively inexpensive to build—most of the construction cost of a complete plant being expended on facilities to produce the necessary raw materials. Licenses are to be granted by Jersey Standard only to concerns that will undertake immediate construction of conversion units and for their own consumption only.

SYNTHESIS

Pyrolysis was responsible for the tremendous development of the coal tar chemical industry to its present state of importance; analagously, polymerization and its many applications has had an amazing effect on the youthful chemical synthesis of petroleum so



that it bids fair to compete with the former over a wide field, constant research now making possible the production of rubber substitutes a commercial reality.

Early attempts at production of synthetic rubber as such (an exact duplication of molecular structure) failed both technically and on the score of excessively high cost. The underlying motive of research was low cost rather than high quality, and the excessive fluctuation of natural rubber prices failed to provide a substantial basis for such a new industry.

Vegetable rubber was recognized as a hydrocarbon as early as 1860, and is made up of isoprene molecules. About 40 years ago it was discovered that 2,3-dymethyl butadiene, a hydrocarbon similar to isoprene, could be polymerized slowly into a rubber-like substance; this process was used by Germany during the World War to produce a low-grade rubber substitute at an ultimate rate of 2,000 tons per annum. After the armistice the production of synthetic rubber was abandoned and was regarded as no longer a practicable proposition from the technical standpoint.

Vulcanizing and compounding of natural rubber, and its more recent incorporation with structural materials, have opened vast fields for application of this product. But no matter in what way the raw material may be processed, it is always C_5H_8; half a century of inexhaustible research has not enabled the manufacturer to produce an oil-proof, acid-proof, oyxgen-proof material with the required elastic properties.

A new program of research was commenced having in mind the production of an elastic resin which would have similar or improved structural characteristics of the rubber molecule, but would surpass it in those specific properties outlined above. In 1927, I. G. Farbenindustrie discovered a process by which coal and limestone could be converted into butadiene, which was polymerized into an elastic resin of the type sought. This was named Buna after the two materials utilized for polymerization at that stage—butadiene and natrium (sodium).

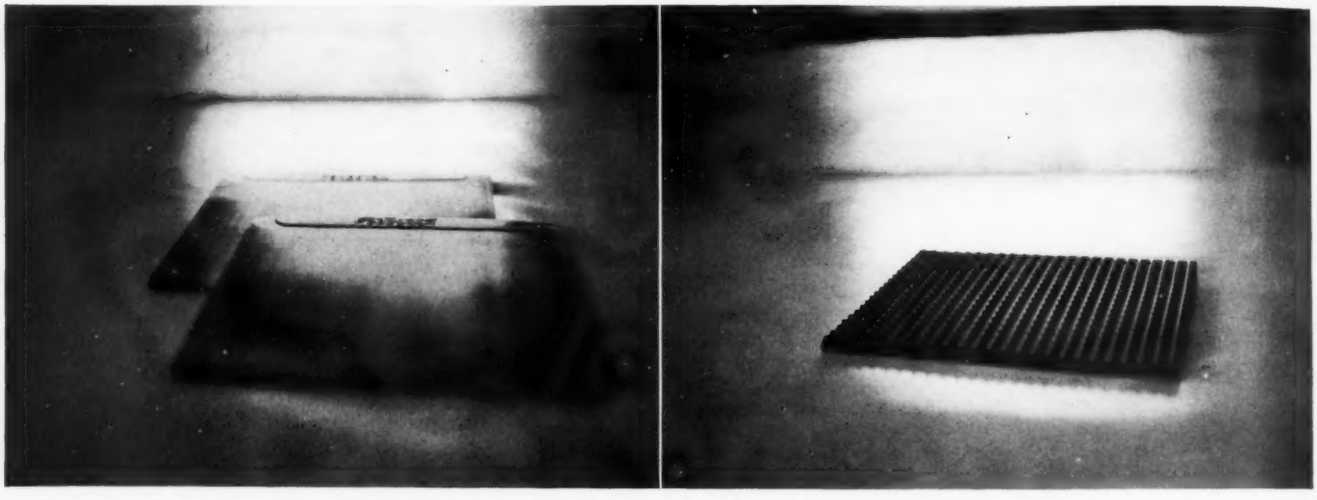
Realizing that petroleum rather than coal would be the ideal source material, Standard Oil Company of New Jersey was interested in the process through a jointly-owned development company. After more than ten years of co-operative research, the German concern assigned its interest in the United States and certain other territory to Jersey Standard.

The joint experimental research had proved that still better products were obtainable from combination of butadiene with styrene or acrilo-nitrile, as well as other substances. Mineral rubber made from butadiene and styrene is called Buna-S, and has a greater resistance to abrasion than natural rubber. Buna-N, renamed Perbunan, is the product resulting from polymerization of butadiene and acrilo-nitrile; it not only has most of vegetable rubber's desirable features but is superior in resistance to deterioration in heat, acid, and oil; in its resistance to abrasion; and in aging qualities. Perbunan Extra (Buna-NN) is a co-polymer of butadiene with a higher percentage of acrylo-nitrile.

Structurally, the vegetable rubber molecule may be considered a polymer of isoprene, or 2-methyl butadiene. Perbunan is the result of polymerizing low molecular weight unsaturated compounds, but the course of polymerization is not necessarily the same as that for natural rubber. With vegetable rubber it is accepted that the diolefin, isoprene, is polymerized through a 1-4 addition, head to tail, making a long straight chain molecule. But the diolefin used for producing Buna is butadiene, which when polymerized by sodium may add on to other units of butadiene through 1, 2 and 3, 4 addition as well as the 1, 4. Therefore, a molecule of ordinary Buna would have a spatial structure with cross-bridging as well as long straight chains. Such a polymer, *i.e.*, one made from butadiene by sodium polymerization, would be expected to be harder, tougher and more resin-like than the vegetable molecules—which is verified by properties of Buna revealed in the rubber mill. Through ozone analysis it has been shown that the so-called interpolymers or co-polymers, which usually consist of butadiene with another olefin and which are polymerized in emulsion, are not so subject to cross-bridging as are the ordinary butadiene polymers made by sodium polymerization.

Perbunan is an interpolymer of butadiene with acrylo-nitrile made in emulsion and is more easily broken down or degraded in molecular weight than are the so-called "numbered" Bunas which are straight butadiene polymers. So this difference may be ascribed to the fact that Perbunan molecules do not contain so much cross-bridging, although a certain amount does take place—which in turn accounts for the difficulty in masticating Perbunan on the rubber mill in comparison with vegetable rubber.

The original method of Buna production was by bulk polymerization of Butadiene with metallic sodium as the promoter. This slow procedure did not lend itself to production of co-polymers containing polar compounds, and was abandoned in favor of emulsion polymerization. Emu'sion technique is used now to produce co-polymers of the Buna-S and Perbunan type. The raw materials are all obtainable from petroleum; butadiene by cracking of gas oil and acrylo-nitrile by cracking gas oil and combining the product with nitrogen. To produce Perbunan, for example, these two materials are emulsified with water and then subjected to the conditions of temperature and pressure required for converting the emulsion into a viscid, whitish suspension of Perbunan in water. This operation requires careful control



Perbunan may be worked up with carbon black or other reinforcing materials in a similar manner to vegetable rubber in either sheet or moulded form; it is slightly glossier than the natural product.

Test strips of Perbunan and natural rubber are immersed in gasoline (left) and it soon becomes apparent that the vegetable product is subject to severe swelling. Compared with the original size these two test strips (right) show that while the Perbunan is only slightly larger and virtually as strong as it was before immersion, the vegetable rubber strip has swollen greatly and is no longer tough; jelly-like, it may be easily torn with the fingers.

but the problems encountered do not vary greatly from those encountered in other industrial chemical processes, and polymerization takes place more rapidly than when older methods were employed. The suspension resembles vegetable latex drawn from a rubber tree and, similarly, a coagulent is employed to effect a separation; after which the pure Perbunan is removed and dried. In appearance it resembles a cross between pale crepe and smoked sheet, having a distinct rubbery feel and a slight, pleasant odor.

PROPERTIES

Where vegetable rubber polymers have an actual unsaturation of virtually 100 percent of the theoretical, the Buna polymers have appreciably less than the theoretical. It is probable that the molecule has been strengthened through consumption of some of the double bonds by cross-bridging; this greater toughness, in turn, requires more severe processing in the rubber mill to bring about the desired molecular break-down. As the molecular weight is reduced this distinction becomes less noticeable.

The greater chemical inertness of the resulting co-polymers is probably accounted for by further reduction of chain unsaturation with incorporation of styrene or acrilonitrile. Superior heat resistance, resistance to abrasion and aging qualities characterize both of these products. Perbunan resists swelling in various organic solvents to a remarkable extent while Buna-S has better electrical properties than does vegetable rubber.

Heat plasticization, possible with Buna-S, does not facilitate the mastication of Perbunan, and it is necessary to accept the fact that Perbunan is naturally harder, tougher and drier than vegetable rubber. Difficulties encountered by some factories in calendering, tubing or general processing can be for the most part laid to improper mastication. It is a paradox that Perbunan does not become plastic on the mill like rubber, yet, it must be properly masticated to give easy processing properties. Perbunan must and can be masticated readily if the mill rolls are set more closely than they are for rubber, if they are kept cold (temperature not to exceed 75 deg. C.), and the batch feed should be small enough to pass continuously through the bite of the rolls (25 to 35 lb. of crude Perbunan should be maximum quantity for a 60 in. mill).

It is important to use softeners because of Perbunan's resistance to break-down. Not only may the regular softeners be employed, but others are also effective. These include: dibenzyl ether, phthalic acid esters, tricresyl phosphate, triphenyl phosphate, wool grease, pine tar, coal tar and vegetable rubber itself (although not usable in large proportions where oil resistance is desired). Sulphur content of Perbunan need not be quite so high as for vegetable rubber to induce a good vulcanizate—1.0 to 2.5 percent on the Perbunan is adequate. Over-vulcanization

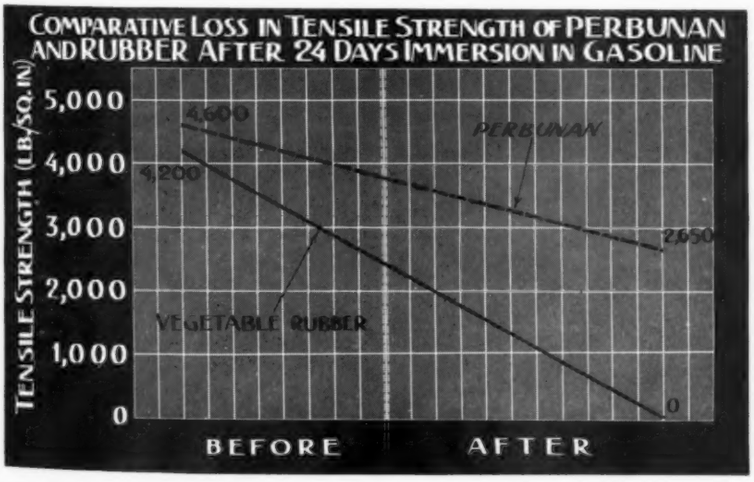


Figure 2: Both stocks contain 45 percent gas black on the gum content.

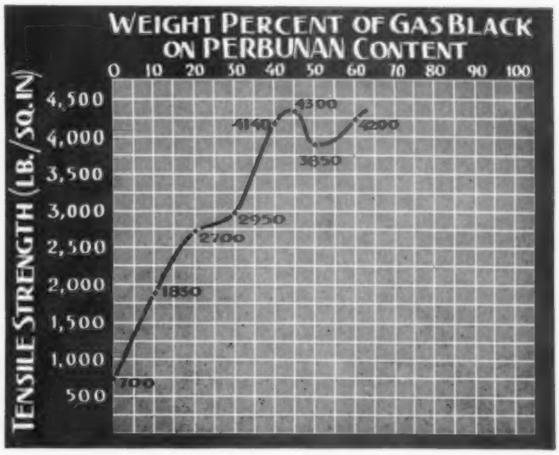


Figure 3: Perbunan reinforcement by gas black.

and reversion, problems with vegetable rubber, present no difficulties. Perbunan vulcanizates tend to harden after prolonged periods of heating rather than to soften, while there is a stiffening, rather than occurrence of tackiness or resinification, during aging. This phenomenon has also been observed when Perbunan has been subjected to steam or hot air for prolonged periods.

Vegetable rubber progressively loses its elastic properties when it is compounded to make it oil resistant. It is soluble and swells in most oils and organic solvents, and this natural characteristic is not changed by compounding. Perbunan and other mineral rubbers are inherently oil-resistant, and this natural characteristic cannot be noticeably harmed. Figure 1 brings out the resistances of Perbunan in comparison with vegetable rubber in a variety of solvents, one of which has an effect only on the Perbunan while several have effect only on the natural rubber. Figure 2 shows the greater retention of tensile strength by the mineral product after protracted immersion in gasoline.

This resistance to oil is a phenomenon as yet inexplicable. It evidently is produced by the nitrile groups in the polymer and not merely because there are substituents protruding from the main long polymer chain, for the methyl rubber manufactured in Germany during the World War was not oil resistant, while Buna-S (which is made under the same conditions as Perbunan, but with styrene replacing the acrylo-nitrile as a component) is but a little more oil resistant than vegetable rubber itself.

Perbunan seems to have a virtual affinity to carbon black and carbon black reinforcement takes place in a magnified degree. A pure gum Perbunan vulcanizate with tensile strength of about 800 lb. per sq. in. jumps up to 4,500 to 5,000 lb. per sq. in. when 40 to 50 percent of channel gas black are added. This progressive increase is indicated graphically in Figure 3.

Practically all Perbunan stocks require some form of filler, because of this low tensile strength in its pure gum state which gives it but little practical value at that point. Active gas blacks give a higher tensile strength and abrasion resistance, but other fillers may be used with satisfactory results. These include: finely divided zinc oxides, light calcined magnesia, and magnesium carbonate. Whiting, lithopone and barytes produce but slight reinforcement.

From purely scientific reasoning alone, the compositions produced by means of active gas black stocks are extremely interesting. If vegetable rubber could be reinforced to the same degree as Perbunan it would become a remarkable and valuable structural material. After gas black loading Perbunan is increased in tensile strength from 800 to 4,500 or more lb. per sq. in., or about five times. Since vegetable rubber in pure gum form has a tensile strength of 3,500 lb. per sq. in., it would in that event have a projected tensile strength after loading of some 200,000 lb. per sq. in.

It is to be expected that this remarkable property of Buna will form the basis of some highly interesting research in the field of pure science.

FUTURE

Perbunan (and, presumably, Buna-S at some later date) seems to have excellent prospects of commercial production and use on a wide scale. It is more like vegetable rubber than any of the synthesized products currently obtainable and responds to treatment with manufacturing equipment already installed for the natural product. The missionary-work of convincing rubber manufacturers and the consumers that the higher initial cost of mineral rubber is warranted by its superiority in use already has been accomplished; in addition to which Perbunan is to enjoy the advantage of a relatively low price.

When Neoprene, probably its most important rival, was introduced, this DuPont product was manufactured at a cost of $1.05 per lb., this price holding from 1931 to 1935. Since the latter year the cost has been $0.75 per lb. Perbunan, however, is expected to be produced at an initial cost somewhere between $0.20 and $0.30 per lb., and more nearly approaches the minimum price at which vegetable rubber may be produced and imported to the United States at a profit, namely, about $0.10 per lb.

There has been more than a five-fold increase in consumption of mineral rubber substitutes during the period from 1932 to 1937, and new uses are being discovered at frequent intervals. The U. S. Navy, whose current expansion program calls for construction of several airships, has tested it in fabric for lighter-than-air craft gas cells and learned that it is 25 times better than the finest vegetable rubber for preventing the escape of helium. A more important use is to be in the heavier-than-air craft field; engineers are reducing aeroplane weight by using the wing structure for fuel tanks in both military and commercial models, and the inside must be coated with this substance to make it oil-tight. Resistance to corona makes mineral rubber highly valuable in the high voltage electrical field.

Standard Oil Development Company has been informed by at least two large rubber manufacturers that they will be purchasing Perbunan while one of them, Firestone Tire and Rubber Company, has obtained a license to construct a processing plant using Jersey Standard's process at Akron, Ohio, for the immediate production of Buna. The Baton Rouge plant is being built by Standard Oil Company of Louisiana, associate company of Standard Oil Development Company. Other plants may follow—probably at either Bayonne or Bayway, which are convenient to America's second largest rubber manufacturing center, in eastern New Jersey.

The initial production of Perbunan in the United States oil industry is being planned to supply the demand for specialty purposes. The chemicals consumed in the manufacture of these and other rubber polymers are petroleum derivatives, and the oil industry's past record for large-scale operation at low cost bodes well for the future expansion of this new elastic product of petroleum synthesis.

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Goodrich and Phillips Form Synthetic Rubber Company

To INCREASE the production of synthetic rubber so that additional commercial quantities can be made promptly available for use in national defense and throughout industry, David M. Goodrich, chairman of the board of The B. F. Goodrich Company and Frank Phillips, chairman of the board of Phillips Petroleum Company, announced the formation of Hydrocarbon Chemical and Rubber Company on July 31.

"This is concrete evidence of the willingness and ability of American industries voluntarily to pool their knowledge and resources for the benefit of the nation's defense program," the statement said.

"The new organization brings together, for the purpose of strengthening immediately, the nation's defense position with respect to vital rubber supplies, two major companies, each possessing a broad background of experience in research, production and use of hydrocarbon products. The close coordination between these two companies accomplished by the formation of Hydrocarbon Chemical and Rubber Company will hasten the day when, if necessary, every American tire as well as the thousands of other rubber products can be made wholly with American rubber," the statement said.

"Phillips Petroleum Company has a strong patent position in the processing of petroleum hydrocarbon and possesses immediate supplies and vast reserves of the raw materials used in the manufacture of synthetic rubber," it was pointed out. The Goodrich Company announced seven weeks ago, on June 5th, the commercial production of the nation's first automobile tires made from synthetic rubber, after an intensive 14-year independent development program in its rubber research laboratories, which are the oldest in the country.

"In the formation of the new Hydrocarbon Chemical and Rubber Company, Goodrich and Phillips are combining their facilities

David M. Goodrich, left, chairman, The B. F. Goodrich Company, and Frank Phillips, chairman, Phillips Petroleum Company, signing contracts for the formation of Hydrocarbon Chemical and Rubber Company which will pool resources to manufacture synthetic rubber from petroleum-derived butadiene gas.

for the manufacture of synthetic rubber. These are being rapidly expanded so that samples of materials and detailed technical information relating to military and industrial uses of the new substances may be put in the hands of prospective users", the statement said. Present production is being substantially increased. The new company's principal offices will be located in Akron, Ohio.

The directors of Hydrocarbon Chemical and Rubber Company representing Phillips Petroleum Company are Frank Phillips, chairman; K. S. Adams, president and G. G. Oberfell, vice-president in charge of research. Representing the B. F. Goodrich Company are David M. Goodrich, chairman; John L. Collyer, president and T. G. Graham, vice-president in charge of production, it was announced.

In charge of sales for the new concern will be Ross W. Thomas, who is general manager of the Philgas division of Phillips and was described as "the man primarily responsible for the spectacular growth of this division, now the largest marketer of liquefied petroleum gas."

Dr. Waldo L. Semon, recognized as one of the nation's outstanding research chemists, will be director of research, it was announced. "Dr. Semon will bring to the Hydrocarbon Chemical organization the years of experience he has gained in the Goodrich laboratories in the development of Ameripol. Dr. Semon made this process commercially practical and proved this new kind of synthetic rubber equal, or superior, to natural rubber for tires and many other rubber products."

The new company acquires from Goodrich its experience in the production and use of synthetic rubbers, and from Phillips the benefits of its vast resources of natural raw materials and its background of hydrocarbon research, in which field, it was stated, the latter company has long been recognized as a leader.

"Over the past 20 years Phillips has pioneered many important advances in this field, among which are the development of the thermal polymerization and alkylation processes and the production of two super-aviation fuels, iso-octane and neo-hexane, which can be combined into the world's most powerful aviation gasoline. Immense reserves of raw materials owned by Phillips assure the new company fullest access to the hydrocarbons necessary for the production of synthetic rubber's butadiene base," the announcement stressed.

The speed with which the company plans to increase its production has been made practical, it was explained, because of the rapid strides within the past few months in developing compounds of these new materials for a large number of commercial needs.

"In fact, it can be said that we have learned almost as much about processing, synthetic rubber in 100 days as was learned about natural rubber in 100 years," the statement declared.

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CANADIAN OIL AND GAS

EARLY in July the first issue of a new oil publication, *Canadian Oil and Gas* made its appearance. The editor is Mr. Charles J. Penn and publication offices are located at 36 Toronto Street, Toronto, Canada.

As is pointed out in the editorial statement of policy, there has long been a conspicuous need for a journal devoted to the oil and gas industry in Canada conducted on sound and constructive lines. This publication is designed to act as a central forum for the analysis and discussion of the industry's many problems in the marketing, refining, transportation, production, exploration and legal divisions of the oil industry. Long an important consuming and refining center of petroleum, Canada, in recent years has become also a significant producer of petroleum and as such, it is entitled to a publication of its own dealing with this important industry.

The publication enjoys the support and approval of many of the leading figures of the Canadian Government. In this connection, it may be noted that the first edition carries a message from the Honorable T. A. Crerar, Minister of Mines and Resources, the Honorable James A. MacKinnon, Minister of Trade and Commerce, an article by Mr. E. Swain, Supervisor of Mines in the Department of Natural Resources, and a statement to the publication by the Honorable T. D. Pattullo, Prime Minister of the province of British Columbia. There follow a number of articles dealing with the oil and gas situation as it now exists in Canada. It is noteworthy that the book is unusually well edited, attractively laid out, and liberally illustrated.

In connection with the first edition, the editor states:

> "Features of its editorial policy include opposing strenuously any unfair trading, dangerous price cutting, and unjust taxation, and to be helpful and impartial where government activities in relation to oil are concerned. Orderly development and marketing of the nation's oil and gas resources will be advocated and fostered, and a most efficient and economical means of transportation of domestic crude and refined products will be promoted."

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RIEBER RESIGNS

AS a result of wide-spread publicity linking the name of Captain Torkild Rieber, chairman of the board of The Texas Corporation with Dr. Gerhard Alois Westrick, Captain Rieber resigned from his post with the Texas Company with whom he had served for thirty-six years.

The new chairman of the board has not been designated but it is understood that W. S. S. Rodgers, president, would act as chairman until a new chief executive has been elected.

Following a seven-hour meeting of the Board of Directors, Captain Rieber issued a statement in which he said that it was with real regret that he announced his resignation. He was doing so, however, in order to avoid repercussions that might be harmful to the company to which he had devoted some thirty-six years of his active business career. He stated that as far as he knew, Dr. Westrick "was here only in the interest of promoting business between the United States and Germany and in furtherance of that end, he had seen many prominent business and professional men in this country." Captain Rieber insisted that "under no circumstances could he be identified with or sympathetic to any kind of un-American activities."

Foreign Oil Legion

James Kewley

ON the conclusion of thirty-four years of continuous service with Shell interests James Kewley, chief chemist of Asiatic and Anglo Saxon Petroleum Companies retired on June 30. Mr. Kewley joined the Shell organization in 1906 directly on leaving Cambridge University and shortly afterward went to Netherlands India as chief of the control laboratory at Balik Papan. Later he was transferred to Egypt as manager of the refinery of Anglo-Egyptian Oilfields, Ltd. At the outbreak of the first world war he was recalled to England to direct work in connection with the production of explosives in which he performed services of great importance to the government.

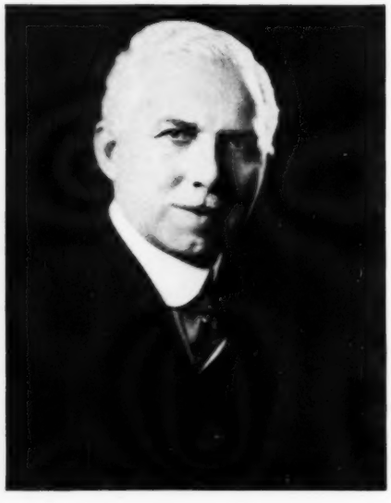
In 1919 Mr. Kewley organized the chemical department of the Shell group at the head of which he remained until his retirement. In this position he became one of the outstanding figures in the chemical branch of the industry, not only through his services to his own companies, but through the active part he took in promoting technological research. He was one of the organizers of the Institute of Petroleum and was its president from 1931 to 1933. Much of the success of the World Petroleum Congress held in London in 1933 was due to his labors and he presided over its deliberations with an ability that won widespread praise.

Though of conservative habit Mr. Kewley kept always abreast of progress in the petroleum industry and was responsible for the early adoption of many improvements in the refining art. He was keenly interested in the technical training of young men and guided the early course of many men now prominent in the refining branch of the industry. He presented a large number of papers before technical societies and was the author of the "Petroleum Handbook" used as a reference book in the Shell organization and of a technical work, "Petroleum and Allied Industries" published in 1922.

Through his many activities Mr. Kewley acquired a wide circle of friends and acquaintances in all parts of the world who extend the hope that he may long enjoy his well earned retirement.

H. D. COLLIER was elected president of the Standard Oil Company of California according to an announcement of the Board of Directors issued on July 8th, 1940. Mr. Collier succeeds the late W. H. Berg. Mr. Collier acted as chief engineer on Pacific Coast freight boats until July of 1903 when he became a petroleum salesman for Standard of California's Seattle sales agency. After several advancements in the company's sales department Mr. Collier was made general manager of domestic refined and lubricating sales in 1922. In January of 1924, he became a member of the Board of Directors and in 1931, vice-president of the company. While his interest was primarily in the sales department, his years of experience on the Board made him familiar with other basic problems facing an international oil company of the size and ramifications of the Standard Oil Company of California. He is a director of the American Petroleum Institute and a member and leading organizer of a number of civic associations in San Francisco.

H. D. Collier



Frank A. Howard

FRANK A. HOWARD, president of Standard Oil Development Company has been elected a vice-president of Standard Oil Company (N. J.)., according to an announcement released on July 24. Mr. Howard will coordinate the extensive interest of the Jersey company in chemical, research and patent matters. He joined the Standard Oil organization in 1919, eight years after graduating from the Engineering School of George Washington University. In 1922, the general technical and patent departments of the company were organized as the Standard Development Company and in that year Mr. Howard was elected president of the new company. Other affiliates which will come under the direct control of Mr. Howard, are: Standard Alcohol Company, Standard I. G. Company, Jasco Inc., Hydro Patents Company, Ethyl Gasoline Corporation and others.

Left to right. John H. Baird, J. H. Teer, R. R. Heath and H. McAdams at Bonnie Briar.

JOHN H. BAIRD, president of the New York Chapter of the Nomads organization invited members of this chapter to attend a golf tournament and outing at the Bonnie Briar Club in Westchester County on the 17th of July. A large number of the members attended and the morning and afternoon was devoted to golf, tennis and swimming, followed by dinner at the club house and an informal meeting.

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Chester Crebbs

CHESTER CREBBS, President of the Mene Grande Oil Company of Venezuela sailed from New York on the 12th of July via the SS. SANTA ROSA on his way to his home in Caracas, Venezuela. Mr. Crebbs was completing a brief visit to New York on business of his company.

A. H. T. CHISHOLM, formerly with the Anglo-Iranian Oil Company, Ltd., who successfully negotiated the Kuwait Oil Concession has recently been appointed editor of the FINANCIAL TIMES of London. Mr. Chisholm is the proud father of a daughter born in London on July 27th.

CHESTER BAIRD, Chief Geologist of the Mene Grande Oil Company of Venezuela who has been in charge of the Gulf Oil Corporation's exploration work in Denmark until the outbreak of hostilities in Europe sailed for Venezuela aboard the SS. SANTA PAULA for a two-year stay in South America.

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Chester Baird

THE 11th annual Axelson employees picnic was held on Saturday, July 27th at the American Legion Stadium at Montebello, California. Over 1,500 Axelson employees attended the picnic which lasted from 8.30 in the morning to 5:30 at night.

← *L. P. St. Clair recently designated oil umpire of California succeeding J. R. Pemberton.*

Left to right, Jack Axelson; C. F. Axelson, retired; J. C. Axelson, president, Axelson Manufacturing Co.; G. A. Axelson, retired; and D. F. Axelson, vice-president.

WORLD OIL P

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specifi

U. S. BARRELS

	July 1939	Aug. 1939	Sept. 1939	Oct. 1939	Nov. 1939	Dec. 1939	Jan. 1940	Feb. 1940	March 1940	April 1940	May 1940	Preliminary Figures June. 1940
United States	110,937,000	80,865,000	108,168,000	114,197,800	111,887,000	114,808,500	113,140,700	108,668,800	120,075,000	116,046,000	118,283,000	113,394,000
Soviet Union[4]	18,200,000	18,100,000	18,000,000	18,406,932[1]	17,813,160[1]	18,406,932[1]	18,406,932[1]	17,251,723[1]	18,454,796[1]	17,896,740[1]	18,448,875[1]	17,853,750
Venezuela	18,015,182	18,743,714	18,652,354	19,516,845	16,681,881	16,050,535	14,798,667	14,380,134	15,514,962	16,495,995	18,343,406	15,697,320
Iran[5]	6,637,503[1]	6,637,503[1]	6,423,390[1]	6,637,503[1]	6,423,390[1]	6,637,503[1]	6,637,503[1]	6,227,895[1]	6,745,073[1]	6,507,180[1]	6,560,000[1]	6,449,520
Netherland India: Sumatra	3,557,020	3,550,123	3,502,437	3,600,371	3,427,490	3,629,655	3,472,786	3,149,536	3,440,792[1]	3,428,880[1]	3,456,624[1]	3,345,120
Borneo	1,156,942	1,111,810	865,693	995,207	1,068,349	1,086,713	1,093,743	1,062,210	1,097,516[1]	1,063,890[1]	1,106,080[1]	1,070,100
Java[3]	565,181	559,096	511,355	556,658	549,926	633,136	561,064	507,207	562,665[1]	537,720[1]	555,582[1]	537,600
Molucca[9]	73,962	71,767	68,065	64,292	62,340	60,550	59,215	62,340	54,021[1]	67,740[1]	62,310[1]	60,300
Roumania	3,902,208	3,945,625	3,795,308	3,842,567	3,743,041	3,842,154	3,786,908	3,595,888	3,818,554	4,422,721	4,002,844[1]	3,350,000
Mexico[15]	3,245,000	3,700,000	4,050,000	4,500,000	3,700,000	3,500,000	3,348,682	3,147,385	3,286,000	3,180,000	3,412,000	3,873,720
Iraq	2,807,402	2,615,129[1]	2,530,770[1]	2,615,129[1]	2,530,770[1]	2,615,129[1]	2,615,129[1]	2,461,723[1]	2,666,713[1]	2,578,020[1]	2,644,362[1]	2,559,000
Colombia	1,798,271	1,950,966	1,894,941	1,860,620	1,918,891	1,871,594	2,484,398	2,025,618	2,203,272	2,192,178	2,281,538[1]	2,207,940
Trinidad	1,620,564	1,636,645[1]	1,583,850[1]	1,636,645[1]	1,583,850[1]	1,636,645[1]	1,636,645[1]	1,529,808[1]	1,633,421[1]	1,580,940[1]	1,634,754[1]	1,582,020
Argentine	1,508,738	1,495,806	1,542,755	1,632,997	1,621,927	1,691,123	1,751,910	1,797,072	1,625,981[1]	1,579,350[1]	1,730,420[1]	1,674,600
Peru[6]	1,100,000[1]	1,100,000[1]	1,116,810[1]	1,154,037[1]	1,116,810[1]	1,154,037[1]	1,154,037[1]	1,071,869[1]	1,139,932[1]	1,097,400[1]	1,143,466[1]	1,106,280
Bahrein[6]	671,892	698,714	647,595	571,673	563,985	632,962	631,644	581,255	636,577	579,078	616,174	600,930
Burma[7]	650,828	696,317	685,756	710,501	753,771	708,054	666,810[1]	629,039[1]	689,750[1]	666,810[1]	679,520[1]	657,000
Canada[7]	899,169	795,844	720,866	816,257	731,209	502,920	486,859	655,586	570,131	634,869	601,400[1]	582,000
Brunei[7]	490,318	488,777[1]	473,010[1]	488,777[1]	473,010[1]	488,777[1]	488,777[1]	456,576[1]	487,661[1]	471,540[1]	487,940[1]	472,200
Great Germany: Old Reich[14]	391,098	381,114[1]	368,820[1]	381,114[1]	368,820[1]	381,114[1]	381,114[1]	360,383[1]	386,508[1]	371,610[1]	384,183[1]	371,700
Ostmark[13]	85,131	58,869[1]	56,970[1]	58,869[1]	56,970[1]	58,869[1]	58,869[1]	57,972[1]	61,721[1]	61,230[1]	61,194[1]	59,220
Slovakia and Moravia	11,000	11,000[1]	9,810[1]	10,137[1]	9,810[1]	10,137[1]	10,137[1]	9,454[1]	10,106[1]	9,780[1]	10,106[1]	9,720
Poland	330,000[1]	330,000[1]	320,370[1]	331,049[1]	320,370[1]	331,049[1]	331,049[1]	310,155[1]	331,669[1]	320,790[1]	331,421[1]	320,730
Japan[16]	222,072	210,105	222,513	223,016	224,494	223,960[A]	225,308[1]	210,801[1]	224,068[1]	216,960[1]	224,719[1]	217,470
British India[11]	175,932	200,036	212,322	229,422	213,270	228,281	197,532[1]	180,351[1]	189,999[1]	180,090[1]	191,611[1]	185,430
Ecuador	206,868	204,115	193,720	193,382	196,808	205,138	204,509	188,024	211,610	208,513	213,000	201,650
Saudi Arabia	342,558	429,104	538,136	512,590	313,757	437,020	491,663	323,416	606,201	476,359	334,728	356,571
Sarawak[12]	107,961	112,716[1]	109,080[1]	112,716[1]	109,080[1]	112,716[1]	112,716[1]	104,951[1]	112,282[1]	108,330[1]	112,282[1]	108,660
Egypt[10]	436,519	440,678	362,880	420,519	434,174	446,846	438,367	376,043[1]	432,729[1]	454,260[1]	435,891[1]	421,830
Italian Empire: Albania[16]	140,025	89,000[1]	114,540[1]	118,358[1]	114,540[1]	118,358[1]	118,358[1]	112,230[1]	123,411[1]	119,250[1]	121,241[1]	117,330
Italy	6,843	7,600[1]	7,736[1]	7,750[1]	7,500[1]	7,750[1]	7,750[1]	7,250[1]	7,657[1]	7,380[1]	7,688[1]	7,440
France	42,000[1]	42,000[1]	42,653[1]	42,470[1]	41,160[1]	42,532[1]	42,532[1]	39,817[1]	42,439[1]	41,100[1]	42,470[1]	41,100
Hungary	70,000[1]	70,000[1]	65,210[1]	65,317[1]	65,210[1]	65,317[1]	65,317[1]	62,350[1]	67,580[1]	65,580[1]	66,805[1]	64,650
Bolovia	8,700[1]	8,700[1]	7,893[1]	8,556[1]	8,280[1]	8,556[1]	8,556[1]	7,975[1]	8,587[1]	8,310[1]	8,556[1]	8,280
Other Countries[17]	50,700	50,700	50,000	49,073	47,490	49,073	49,073	45,849	49,786	48,150	49,383[1]	47,790
WORLD TOTAL	180,464,587	151,408,573	177,915,608	186,599,149	179,182,533	182,683,635	179,965,259	171,657,785	187,569,170	183,624,743	188,645,573	179,614,441

[A] Estimated official sources.
[1] Estimated W. P.
[3] Includes natural gasoline (naphtha) production.
[5] International Petroleum Company and Lobitos Oilfields, Ltd. figures combined.
[4] Russian Saghalin included with U.S.S.R.
[5] Anglo-Iranian Oil Company, Ltd., figures revised —fuel oil returned to the ground has been deducted.
[6] Bahrein Petroleum Company, Ltd., figures.
[7] Does not include Assam or Punjab, which are listed together under British India.
[8] British Malayan Petroleum Company, Ltd., figure
[9] Includes Madura.
[9] Includes all other Netherland India.

Daily Averages in Barrels

	Jan.—June 1940	Jan.—June 1939
United States	3,789,052	3,444,149
Soviet Union	595,125	595,580
Venezuela	523,244	542,116
Iran	214,984	214,113
Netherland India: Sumatra	111,504	112,098
Borneo	35,680	37,298
Java	17,922	17,642
Molucca	2,010	2,346
Roumania	129,124	126,303
Mexico	108,373	92,448
Iraq	85,302	83,297
Colombia	73,598	59,344
Trinidad	52,734	52,884
Argentine	55,820	50,370
Peru	36,886	37,824
Bahrein	20,031	21,004
Burma	21,920	20,263
Canada	19,400	18,625
Brunei	15,740	15,759
Great Germany: Old Reich	12,393	12,239
Ostmark	1,974	1,754
Slovakia and Moravia	326	317
Poland	10,691	10,693
Japan	7,249	7,330
British India	6,181	5,929
Ecuador	6,743	6,144
Saudi Arabia	14,224	7,517
Sarawak	3,622	3,663
Egypt	14,061	11,393
Italian Empire: Albania	3,911	3,861
Italy	248	254
France	1,370	1,370
Hungary	2,155	2,044
Bolivia	276	277
Other Countries	1,593	1,552
WORLD TOTAL	5,994,928	5,619,567

Official Crude Oil Production Figures for 1933 to 1939 (Revised) in Barrels

	1939	1938	1937	1936	1935	1934	1933
United States	1,264,256,000	1,214,355,000	1,279,160,000	1,098,516,000	996,596,000	908,065,000	905,656,000
Soviet Union	216,727,024	206,192,000	201,856,661	199,635,921	184,008,033	175,635,783	155,596,429
Venezuela	205,783,585	188,429,050	187,675,477	155,270,840	148,809,057	136,098,681	117,113,940
Iran	78,151,332	78,320,840	78,109,001	62,977,950	57,520,488	57,902,092	54,440,075
Netherland India: Sumatra	41,557,020	34,538,128	33,451,511	30,469,428	28,004,595	26,336,011	22,345,172
Borneo	13,125,425	12,812,383	12,960,072	13,068,910	13,529,185	14,335,543	15,003,175
Java	6,568,660	6,955,283	7,152,931	3,618,293	3,462,440	3,778,920	3,600,816
Molucca	836,144	607,622	537,436	375,823	311,872	273,698	285,335
Roumania	45,931,846	48,366,000	52,395,725	63,532,846	61,270,072	61,849,306	53,919,700
Mexico	39,428,141	38,505,824	46,455,687	41,027,915	40,240,563	38,171,946	34,000,830
Iraq	30,791,132	32,404,000	30,603,660	29,913,150	27,410,983	7,639,849	1,094,915
Colombia	22,036,613	21,581,588	20,297,543	18,756,110	17,597,655	17,337,900	13,156,126
Trinidad	19,270,256	17,736,176	15,502,989	13,237,030	11,671,224	10,894,363	9,561,353
Argentine	18,613,167	17,076,237	16,354,717	15,457,960	14,297,025	14,021,901	13,690,554
Peru	13,587,906	15,908,279	17,459,112	17,593,069	17,056,555	16,314,381	13,257,311
Bahrein	7,588,554	8,297,998	7,762,264	4,644,635	1,264,807	285,072	31,377
Burma	7,872,981	7,499,498	7,847,553	7,587,718	7,181,113	7,278,859	7,114,311
Canada	7,837,503	6,965,457	2,996,033	1,507,931	1,447,204	1,410,895	1,145,333
Brunei	5,755,164	5,387,214	4,397,038	3,296,938	3,302,905	2,705,350	2,035,658
Great Germany: Old Reich	4,487,491	3,850,044	3,148,300	3,076,858	2,967,438	2,204,402	1,656,602
Ostmark	693,247	370,038	221,266	50,092	44,347	27,965	5,765
Slovakia and Moravia	119,380	132,005	123,474	126,603	136,580	177,797	121,695
Poland	3,898,044	3,828,438	3,799,862	3,869,575	3,901,881	4,011,336	4,174,679
Japan	2,652,930	2,511,184	2,487,841	2,403,072	2,294,878	1,872,837	1,504,432
British India	2,332,467	2,330,209	2,161,653	1,978,329	2,037,810	1,921,863	1,628,803
Ecuador	2,312,118	2,257,278	2,161,436	1,942,467	1,731,785	1,636,619	1,619,902
Saudi Arabia	3,933,904	495,135	64,968	19,777	Nil	Nil	Nil
Sarawak	1,327,327	1,624,882	1,655,565	1,547,882	1,776,593	1,942,591	2,206,815
Egypt	4,602,797	1,561,231	1,163,267	1,262,666	1,255,151	1,527,252	1,653,535
Italian Empire: Albania	1,393,727	437,597	380,292	219,693	41,218	17,500	11,437
Italy	91,330	106,083	112,700	129,653	128,615	162,449	213,534
France	500,815	516,240	507,067	534,063	529,664	700,000	786,366
Hungary	769,092	330,829	13,910	100	Nil	Nil	Nil
Bolivia	100,885	106,620	123,123	104,746	163,295	157,875	111,973
Other Countries	578,036	243,000	70,000	37,100	32,300	64,000	54,100
WORLD TOTAL	2,075,512,043	1,982,639,390	2,041,170,134	1,797,791,150	1,652,023,331	1,516,760,036	1,438,797,443

PRODUCTION

Figures in U. S. barrels of 42 gal.—Conversion ratios used are weighted averages for individual countries

METRIC TONS

	July 1939	Aug. 1939	Sept. 1939	Oct. 1939	Nov. 1939	Dec. 1939	Jan. 1940	Feb. 1940	March 1940	April 1940	May 1940	Preliminary Figures June 1940
United States	15,009,700	10,941,000	14,635,096	15,450,953	15,138,276	15,533,757	15,307,901	14,702,854	16,246,164	15,700,987	16,003,653	15,342,172
Soviet Union[4]	2,500,000	2,480,000	2,300,000	2,508,024[1]	2,427,120[1]	2,508,024[1]	2,508,024[1]	2,360,194[1]	2,531,522[1]	2,436,780[1]	2,520,021[1]	2,438,790
Venezuela	2,674,860	2,783,031	2,769,466	2,897,824	2,476,894	2,383,153	2,197,278	2,135,135	2,303,632	2,449,294	2,723,594	2,330,700
Iran[5]	880,493[1]	880,493[1]	852,090[1]	880,493[1]	852,090[1]	880,493[1]	880,493[1]	826,152[1]	894,753[1]	863,190[1]	870,212[1]	833,540
Netherland India: Sumatra	455,386	454,503	448,398	460,936	438,803	464,685	444,602	403,218	440,506[1]	438,960[1]	432,525[1]	426,270
Borneo	148,117	142,339	110,830	127,411	136,775	139,126	140,026	135,989	140,509[1]	136,290[1]	141,608[1]	137,040
Java[9]	72,357	71,578	65,466	71,266	70,404	81,057	71,830	64,935	72,035[1]	68,820[1]	71,114[1]	69,210
Molucca[9]	9,469	9,188	8,842	8,231	7,981	7,752	7,581	7,981	6,916[1]	8,670[1]	7,967[1]	7,710
Roumania	529,113	535,000	514,618	521,026	507,531	520,970	513,479	487,578	517,770	599,691	542,740[1]	525,240
Mexico[10]	476,505	543,316	594,713	660,973	543,318	513,950	492,094	462,171	482,525	466,960	501,028	491,923
Iraq	375,271	349,556[1]	338,286[1]	349,556[1]	338,280[1]	349,556[1]	349,556[1]	330,034[1]	356,531[1]	344,670[1]	353,741[1]	342,330
Colombia	247,017	272,101	264,287	257,920	267,627	260,524	346,499	282,512	307,290	305,745	318,184[1]	307,920
Trinidad	227,927	230,206[1]	222,780[1]	230,206[1]	222,780[1]	230,206[1]	230,206[1]	215,151[1]	229,710[1]	222,360[1]	229,896[1]	222,480
Argentine	214,919	213,077	219,765	232,620	231,043	240,900	249,559	255,993	231,601[1]	224,970[1]	246,481[1]	238,270
Peru[1]	146,000[1]	146,000[1]	147,810[1]	152,737[1]	147,810[1]	152,737[1]	152,737[1]	141,810[1]	150,784[1]	145,200[1]	151,280[1]	146,400
Bahrein[2]	91,551	95,348	87,030	78,012	76,963	86,375	86,195	79,319	87,017	79,022	84,084	82,020
Burma[1]	89,893	96,176	94,717	98,135	104,112	97,797	92,101[1]	86,855[1]	94,147[1]	91,980[1]	93,527[1]	90,510
Canada[2]	114,427	101,278	91,736	103,875	93,052	64,001	61,957	83,429	72,554	80,792	76,508[1]	74,040
Brunei[3]	65,410	65,193[1]	63,090[1]	65,193[1]	63,090[1]	65,193[1]	65,193[1]	60,900[1]	65,038[1]	62,880[1]	65,069[1]	62,970
Great Germany: Old Reich[14]	55,927	58,300[1]	53,190[1]	54,963[1]	53,190[1]	54,963[1]	54,963[1]	51,997[1]	55,800[1]	53,940[1]	55,490[1]	53,700
Ostmark[13]	12,691	13,000[1]	9,030[1]	9,331[1]	9,030[1]	9,331[1]	9,331[1]	9,048[1]	9,827[1]	9,780[1]	9,703[1]	9,390
Slovakia and Moravia	1,600	1,600[1]	1,550[1]	1,519[1]	1,470[1]	1,519[1]	1,519[1]	1,421[1]	1,519[1]	1,470[1]	1,519[1]	1,470
Poland	45,000[1]	45,000[1]	42,960[1]	44,392[1]	42,960[1]	44,392[1]	44,392[1]	41,644[1]	44,516[1]	43,050[1]	44,454[1]	43,020
Japan[9]	31,544	31,721	31,651	31,723	31,933	31,857[A]	32,178[1]	30,131[1]	32,023[1]	31,020[1]	32,085[1]	31,050
British India[11]	24,300	27,629	29,326	31,688	29,457	31,530	27,280[1]	24,911[1]	26,226[1]	24,870[1]	26,443[1]	25,590
Ecuador	27,272	26,910	25,540	25,495	25,947	27,045	26,962	24,788	27,898	27,490	28,081	26,585
Saudi Arabia	46,404	58,129	72,899	72,899	42,503	59,201	66,604	43,812	82,120	64,531	45,344	48,304
Sarawak[12]	13,797	14,539[1]	14,070[1]	14,539[1]	14,070[1]	14,539[1]	14,539[1]	13,543[1]	14,415[1]	13,920[1]	14,446[1]	13,980
Egypt[13]	62,342	62,936	51,810	60,057	62,150	63,817	62,606	53,534[1]	58,125[1]	57,150[1]	59,272[1]	07,360
Italian Empire: Albania[16]	20,987	13,000[1]	17,100[1]	17,670[1]	17,100[1]	17,670[1]	17,670[1]	16,762[1]	18,415[1]	17,790[1]	18,073[1]	17,490
Italy	850	950[1]	961[1]	961[1]	930[1]	961[1]	961[1]	899[1]	930[1]	900[1]	930[1]	900
France	6,000[1]	6,000[1]	5,760[1]	5,952[1]	5,760[1]	5,952[1]	5,952[1]	5,568[1]	5,952[1]	5,760[1]	5,952[1]	5,760
Hungary	9,500[1]	9,500[1]	8,490[1]	8,773[1]	8,490[1]	8,773[1]	8,773[1]	8,381[1]	9,052[1]	8,760[1]	8,928[1]	8,640
Bolivia	1,000[1]	1,000[1]	960[1]	992[1]	960[1]	992[1]	992[1]	928[1]	992[1]	960[1]	992[1]	960
Other Countries[17]	7,100	7,100	7,000	6,975	6,750	6,975	6,975	6,525	7,006	6,780	7,223[1]	6,810
WORLD TOTAL	24,694,749	20,786,697	24,201,311	25,543,320	24,496,649	24,959,773	24,579,008	23,456,102	25,625,820	25,095,432	25,792,175	24,562,544

[1] Estimated Official Sources

[2] Anglo-Egyptian Oilfields, Ltd., figures.

[3] Sarawak Oilfields, Ltd., figures.

[4] Excluding Burma.

[5] Japanese Saghalin, Taiwan (Formosa) and Hokkaido included with Japan.

[9] Includes all other Netherland India.

[10] Official Figures—Petroleos Mexicanos.

[11] Prussia, Thuringia and Baden.

[12] Formerly known as Austria.

[13] Italian imports of Albanian crude oil.

[14] Estimate representing Morocco, Cuba, New Zealand, Barbados, Greece, Algeria, Yugoslavia, Australia, Great Britain, Kuweit and China.

Daily Averages in Metric Tons

	Jan.—June 1940	Jan.—June 1939
United States	512,657	465,989
Soviet Union	81,293	81,806
Venezuela	77,690	80,378
Iran	28,518	28,403
Netherland India: Sumatra	14,209	14,351
Borneo	4,568	4,813
Java	2,296	2,258
Molucca	257	302
Roumania	17,508	17,125
Mexico	15,915	13,599
Iraq	11,411	11,134
Colombia	10,264	8,276
Trinidad	7,416	7,438
Argentine	8,059	7,167
Peru	4,880	5,002
Bahrein	2,734	2,862
Burma	3,017	2,798
Canada	2,468	2,370
Brunei	2,099	2,103
Great Germany: Old Reich	1,790	1,750
Ostmark	313	262
Slovakia and Moravia	49	48
Poland	1,434	1,426
Japan	1,035	1,042
British India	853	818
Ecuador	889	821
Saudi Arabia	1,927	227
Sarawak	466	473
Egypt	1,912	1,626
Italian Empire: Albania	583	578
Italy	30	31
France	192	192
Hungary	288	275
Bolivia	32	33
Other Countries	227	223
WORLD TOTAL	819,291	768,836

Official Crude Oil Production Figures for 1933 to 1939 (Revised) in Metric Tons

	1939	1938	1937	1936	1935	1934	1933
United States	171,053,443	164,346,325	172,822,797	148,707,864	134,912,143	122,913,903	122,601,191
Soviet Union	29,530,168	28,859,000	27,867,025‡	27,384,900	25,241,100	24,092,700	21,330,100
Venezuela	30,533,706	27,845,286	27,733,926	22,945,299	21,990,373	20,112,115	17,293,193
Iran	10,367,112	10,358,495	10,330,480	8,329,289	7,607,500	7,657,970	7,200,093
Netherland India: Sumatra	5,320,320	4,662,836	4,490,137	4,114,710	3,759,006	3,535,035	2,999,352
Borneo	1,680,377	1,719,783	1,739,607	1,773,545	1,815,998	1,924,234	2,013,849
Java	840,950	933,595	960,125	499,097	464,757	510 320	483,331
Molucca	107,047	81,560	72,139	50,446	41,862	36 738	38,300
Roumania	6,228,047	6,603,000	7,153,000	8,704,000	8,394,000	8,473,355	7,387,000
Mexico	5,794,215	5,716,423	6,896,657	6,090,842	5,973,955	5,666,857	5,049,109
Iraq	4,115,845	4,345,000	4,126,185	4,079,066	3,724,231	1,048,108	147,943
Colombia	3,067,568	3,007,935	2,844,251	2,614,092	2,452,635	2,416,432	1,833,606
Trinidad	2,710,515	2,472,943	2,181,676	1,862,796	1,642,446	1,533,122	1,345,532
Argentina	2,651,448	2,432,857	2,330,063	2,202,304	2,036,903	1,997,706	1,950,499
Peru	1,798,557	9,099,885	2,313,691	2,331,454	2,260,903	2,161,990	1,756,867
Bahrein	1,033,472	1,130,734	1,058,557	635,555	173,072	39,008	4,293
Burma	1,087,424	1,039,960	1,083,391	1,047,593	991,456	1,004,951	982,233
Canada	997,391	879,921	378,478	190,495	182,820	178,233	144,686
Brunei	767,700	707,123	576,545	470,991	471,842	386,478	290,808
Great Germany: Old Reich	647,337	552,074	453,451	444,600	427,400	317,500	238,600
Ostmark	109,904	63,468	33,010	7,473	6,616	4,172	860
Slovakia and Moravia	18,103	19,282	18,036	18,665	19,946	25,971	17,776
Poland	522,874	504,678	501,301	510,630	614,760	529,200	550,670
Japan	379,161	356,328	341,040	341,976	326,580	266,520	212,667
British India	322,160	322,125	298,450	273,137	281,072	265,341	224,879
Ecuador	306,824	319,877	306,326	275,293	245,434	231,947	229,578
Saudi Arabia	536,366	66,683	8,070	2,447	Nil	Nil	Nil
Sarawak	171,322	200,126	217,085	221,126	253,799	277,513	315,259
Egypt	657,510	223,058	166,298	177,491	176,436	214,671	232,437
Italian Empire: Albania	208,279	65,313	56,760	32,760	6,152	2,500	1,707
Italy	11,346	13,178	14,000	16,106	15,977	20,180	26,526
France	70,224	72,106	71,008	74,788	74,172	98,025	110,120
Hungary	103,364	42,798	13,910	13	Nil	Nil	Nil
Bolivia	11,904	13,262	15,487	13,197	20,540	19,858	14,085
Other Countries	82,300	34,080	10,000	5,300	4,600	9,100	7,700
WORLD TOTAL	283,844,283	279,111,097	279,482,962	246,449,340	226,610,486	207,971,753	197,034,849

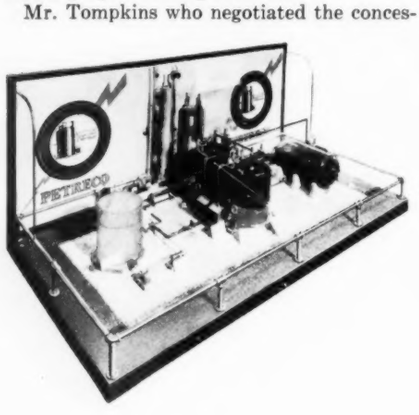
International News and Reports

New Ecuadorian Concession

The Government of Ecuador has recently granted an oil exploration and exploitation concession in the Province of Esmeraldas to H. A. V. Tompkins and Associates of New Orleans and Houston. Of the 88,000 hectares covered by the concession, 50,000 are for exploitation, and the acreage is located on the coast. Preliminary geological studies already have been made, and there are a number of seepages on the property.

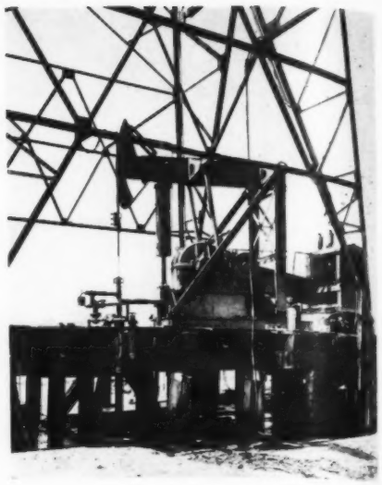
It is planned to send immediately a large and competent party of geologists and geophysists for the purpose of undertaking complete exploration and development of this property. The structures already have been located and the forthcoming operations are for the purpose of detailed studies for deciding upon drilling locations.

Mr. Tompkins who negotiated the concession is an experienced international oil man, having been in the business for 23 years, including time spent in Mexico for the Gulf Co.



Illustrated on the left is a recent development announced by the Airetool Manufacturing Co. which has decreased tube cleaning time 75 percent and labor costs 50 percent in a test demonstration. It is said to have removed much of the danger in cleaning reactor tubes in polymerization units.

ERNO BONEBAKKER, B. Bongers and S. W. Van Bilderbeek of the B. P. M. interest in the Hague presented a gavel inscribed "Ann Onze Zwervende Vrienden" (To Our Roaming Friends) to the Los Angeles Chapter of the Nomads organization. The gavel was accepted by Ted Sutter, president of the Los Angeles Chapter and will be used by succeeding presidents as they come into office. The presentation was made at the regular meeting on July 10th, and was followed by the usual business meeting and a moving picture depicting life in Saudi Arabia and around the eastern Mediterranean by Walton Hoag, Jr., formerly with the California Standard Oil Company. Among the visitors at this meeting were John F. Aston, Ultramar, Argentina; Ross E. Colley, Socony Vacuum, Venezuela; S. W. van Bilderbeek, BPM; W. R. Young, CASOC; Charles R. McGee, Bahia, Brazil; H. R. Jones, CASOC; E. W. Wilkins, Mene Grande Oil Company, Venezuela; R. W. Perry, Ultramar, Argentina; R. M. McCool, Trinidad Petroleum Development Company, Trinidad; Bernard Nicalaas van Dieman de Jel, NKPM, Netherlands India; Dr. F. Brons, BPM; G. H. L. Schepars, NEPM, Netherlands, India; E. M. Trafford, BPM and A. C. Hall, BPM.



World's deepest well pumping off bottom, the El Ray Westermorland No. 1 of the J. E. Pettijohn Company at Western and Imperial Boulevards, Los Angeles, California. The well is pumping from 8,540 ft. using Axelson No. 59, thirty foot rods. Production is 60 bbl. per day.

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Petroleum Industry. Edited by Dr. O. W. Willcox

Alkylation for High Octane Aviation Gasoline—L. J. Coulthurst, before WESTERN PETROLEUM REFINERS' ASSOCIATION, Shreveport, June, 1940.

The four principal processes for the production of iso-octane (the chief component of aviation gasoline) are passed under review. Three of these processes are concerned with the polymerization of butylenes and employ, respectively, cold sulphuric acid, hot sulphuric acid, or phosphoric acid as the catalyzing agent for the polymerization.

These three processes are limited to the use of butylenes as their raw material, and their end-product is a mixture of octylenes, or unsaturated C_8 hydrocarbons. For converting the octylenes into iso-octane it is necessary to hydrogenate them with hydrogen produced at the refinery. Notwithstanding this extra hydrogenation step these processes do not convert all the butylenes available in the charge. From the standpoint of an adequate supply of high-octane fuel for commercial and military purposes the limitation to butylenes as the raw material is a more or less serious handicap on the national interest in peace and especially in wartime.

The fourth process under consideration is the alkylation process, which produces iso-octane without the extra manufacturing steps of hydrogenation and hydrogen manufacture; it has the further distinction of widening the base of raw material supply for making aviation gasoline, because in addition to butylenes it brings isobutane into the operation. There is a large available supply of isobutane in natural gas, enough to complement all the supply of butylenes, which are produced only in refinery cracking operations.

Iso-octane is produced in the alkylation process by first absorbing the butylene in sulphuric acid and then causing the alkyl sulphuric ester thus formed to react with iso-butane. This reaction has long been known but has only recently been technologically developed.

In practice, the butanes and butylenes are mixed in the ratio of 1.2 liquid volumes of iso-

butane to one liquid volume of butylenes; this mixture is contacted with a definite proportion and strength of sulphuric acid; the product, known as "crude alkylate" consists chiefly of isoparaffin hydrocarbons boiling between 80 deg.—300 deg. F. From this total alkylate there is fractionated a 300 deg. F. end-point alkylate which is the desired high octane blending medium for the production of 100 octane aviation gasoline, with use of minimum amounts of tetraethyl lead.

As now developed the alkylation process employs various forms of mixers, chillers, separators, and fractionators, which are described with the aid of flow sheets.

From a charge stock consisting of 120 bbl. of isobutane and 100 bbl. of butylenes (an excess of normal butane will be carried along as a non-reacting diluent which will be recycled) will yield approximately 190 bbl. of alkylate. This yield is twice as great as that from the polymerization-hydrogenation process using the same quantity of butylenes in the charge stock.

As matters now stand the small refiner can hardly afford to install the alkylation process but he can still supply selected straight run gasolines for blending purposes. The natural gasoline manufacturer also has an enlarged market for iso-pentane, which is another constituent of 100 octane aviation gasoline. Refiners with cracking facilities find alkylation directly applicable on account of their butylene production. It has not yet been determined what is the smallest capacity of plant for profitable operation. (The paper has been issued in booklet form by Foster Wheeler Corporation).

DRILLING

Acidizing Illinois Limestones—W. W. Love, in OIL & GAS JOURNAL, Vol. 38 (1940), No. 48, pp. 74-76; 77, 88.

In the Illinois field it continues to be true that acidizing practice must be adapted to the nature of the formation. In the McClosky formation a single treatment gives better results than two treatments, which contrasts with experience in Kansas and West Texas. Some formations require higher pressures on the acid than others. Sometimes the material dissolved out by acid leaves a residue (oolites) that breaks down and requires a new treatment. Quantity of acid varies from 3,000 to 24,000 gals.

Certain limestones dissolve slowly in hydrochloric acid but very rapidly in "intensified" acid. In some formations, especially the McClosky the oil very easily forms an emulsion with the spent acid, hence it is necessary to add to the acid an emulsion preventer, and it is found that different emulsion preventers have to be used with different oils, All these peculiarities have to be given special study, and a thorough program of laboratory testing must precede the acidizing treatment.

In case of thick oil zones having several sections of different porosities they are acidized by putting jelly seals above, or below them, as they may require. In this way the producing zone is developed evenly.

What is described as one of the most important tools yet devised for the chemical treatment of a well is the jet gun, which is used for removal of cement sheaths left on the walls of the producing formation after a cement job, for treating tight wells, and for routine acidizing jobs. The jet gun is a pipe closed at the lower end, where several perforations allow acid to be jetted against the wall of the hole under pressure. The usual practice is to set the gun opposite the most promising part of the formation and turn on the acid followed by oil under pressure to force the acid into the formation. The results obtained by use of the jet gun are said to be highly satisfactory.

Drilling String and Casing Practice in California—Wallace A. Sawdon, in OIL WORLD, Vol. 33 (1940), No. 6, pp. 3-14.

It is self evident that in California, where deep drilling is practiced more extensively than anywhere else, the operators have been able to procure tubular goods that meet the requirements of such operations. This is especially true of drill pipe, which has to have a high torque strength and other qualities that will carry the weight of long strings and resist fatigue and abrasion. Some wells have been drilled below 11,000 feet with 5⅝ inch pipe all the way, and many deep holes have been completed with no string smaller than 4½ inch.

Preference in tool joints vary. The A. P. I. regular, full-hole and internal flush types are common, but recently the practice of welding the joint to the pipe was inaugurated. Stabilizers or rubber protectors have come into use on tool joints and drill pipe to diminish abrasion and whipping.

Long drill collars are extensively used, in some cases up to 360 ft. However, the prevailing opinion is that the maximum length should be that required to give the maximum weight on the bit.

Rotating speeds have gone to 700 r.p.m. or beyond; 400 r.p.m. are not uncommon. It is claimed that high speeds are less detrimental than low speeds if the proper relation between speed and weight is maintained and that the drill pipe above the collar is kept in tension. Low speeds and reduced weight are advisable when penetrating sharply dipping strata that might deflect the bit.

The fastest consistent drilling speed appears to be made in the Rio Bravo field where some wells are drilled to below 11,000 ft. and the oil string landed in less than one month. The rotating speed is often between 400 and 500 r.p.m. One of the fastest wildcat wells drilled in California was drilled to 13,000 ft. with rotating speeds ranging from a top of 575 r.p.m. to a low of 300 r.p.m. not including coring at the bottom which was done at 150 r.p.m. The drill pipe to 10,375 ft. was 5⅝ inch O.D. and the drill collar was made up of four 60-ft. lengths of 8¼ inch O.D. The weight of this collar was approximately 18 tons and the weight carried on the bit was limited to a maximum of 18 tons. From 10,375 ft. down, 4½ inch drill pipe was used and during the deepest drilling only two 60-ft. sections of drill collar were employed.

Drill collars are now so straight and well aligned that they can be divided into 40-ft. lengths for convenient handling. Hexagonal kelleys are preferred to square or octagonal kelleys.

The use of A. P. I. rounded threads has become practically universal where special types of casing are not employed. These special types of casing are characterized by joint design or great strength of the coupling material which, while providing greater strength, reduce the O. D. Safety factors of 1½ to 2 for collapse strength are used. The longest string of casing yet run in crews furnished by companies specializing in this work. The longest recorded string of welded casing is 5087 ft. of 16-in. One 4,800-ft. string of 13⅜ inch was run at the rate of 2.3 hrs. per 1,000 ft. The use of the down-whirler type of float shoe California is 13,000 feet of 7 in. In one instance a 12,000 ft. string was run in 8 hours total elapsed time. Welding of casing is almost entirely confined to surface strings. Butt welds are seldom used; welding is generally done by experienced in cementing is extending. Even in these deep wells the practice of moving the casing up and down during cementing jobs is successfully used, thanks to strength conferred by the new metallurgy and improved joint design.

Gravel Packing Oil Wells in the Gulf Coast Oil Fields—M. L. Cashion and F. B. Markle, before AMERICAN PETROLEUM INSTITUTE, S. W. District, Div. of Production, Houston, March, 1940.

Gravel packing has been used in completing water wells for many years, but it has been applied to oil wells only in recent years and as the first oil wells were gravel packed successfully in the Gulf Coast fields, this paper is a brief history of gravel packing with descriptions of methods and equipment developed and used in the Gulf Coast. Gravel has been extruded successfully through perforated casing to fill the cavities formed by the production of sand, and although gravel packing has been applied primarily to producing oil and gas wells it has been used also in recycling wells with excellent results.

The cost of gravel packing oil wells has depended on so many varying factors that it is very difficult to specify the additional cost above conventional settings. The minimum additional cost would be in the neighborhood of $2,000.00 which would include gravel truck and service, gravel and rig time while gravelling. Over and above this would be the expense of underreaming.

The paper contains numerous details of successful and partly successful gravel packing operations which should interest production engineers.

The opinion is expressed that in some foreign oil countries, particularly Venezuela, where operations are not hampered by proration, gravel packing would offer even greater saving and advantage than in the United States.

Multiple Sand Completions—Bart DeLaat, before AMERICAN PETROLEUM INSTITUTE, Division of Production, Columbus, April, 1940: 13 pages.

Multiple sand or zone completions are defined as those methods of well completion which permit producing from one or more zones selectively, successively, or simultaneously into a common well bore. These methods have had widespread application in the recent developments in the Illinois Basin and adjacent fields. Mention is made of improved logging which is essential to special completions.

Methods of completion are discussed in their logical sequence of development; first, by the use of especially constructed steel liners; second, by the removal of sections of steel casing with newly developed expanding milling cutters expanded by pump pressure applied from the surface; the third method, and the more recent and most generally applied, consists of inserting drillable sections in the casing string, these being composed of magnesium or aluminum alloys such as are used by the airplane industries. Factors dictating the selection of these materials are discussed as each alloy has dissimilar chemical properties and must be used accordingly. The methods of removal are either by chemical or mechanical means. Chemical removal is confined to magnesium casing and has been performed only experimentally upon aluminum casing. The aluminum casing is usually removed by expanding reamer or wall scraper using rotary tools. Both alloys have been successfully removed by shooting, though it is not a general practice.

The practice of multi sand completions is a distinctly improved method having the advantages of control of individual producing strata whether oil, gas, or water bearing, since they may be opened or shut off as desired. Other advantages are that it permits exploitation of marginal formations which would otherwise be undeveloped, and provides a simple means of testing doubtful formations. It results in increased recovery by improved efficiency of completion and production and it increases ultimate recovery as it extends the economic life of producing wells. In addition to being a superior method of well completion, it can be accomplished at less investment cost than any other method of achieving the same results.

This form of completion has been successfully employed in over three hundred wells under greatly varied conditions with no mechanical failures, and it is predictable that it will continue to be applied very generally in the future.

Problems in Deep Cable Tool Drilling, Appalachian District—J. A. Fox, before AMERICAN PETROLEUM INSTITUTE, Division of Production, Columbus, April, 1940; 9 pages.

The author discusses two important problems encountered in deep cable tool drilling in the Appalachian area; these concern the life of the wire drilling cable and the hazard presented by exploding of localized gas pockets with which certain horizons of the area are afflicted.

The problem of improving drilling technique to achieve a longer working life for wire drilling cables is placed first because the cost of wire lines is one of the greatest items of expense chargeable to deep wells (over 5,000 feet). The author's experience indicates that the life of wire drilling cables can be materially extended by drastically reducing the total weight of the tools and at the same time lengthening the drilling stroke. The weight of the tools is reduced by shortening the conventional stem (or bar).

It was found that this procedure demands the use of swivel sockets instead of the usual straight or stiff sockets. This was attended by the difficulty of running swivel sockets at depths greater than 5,000 feet with the wrist pin in the second hole on the crank. By shifting the pin to the third hole, thus lengthening the lift on the drilling string from 34 to 44 inches, no trouble or inconvenience was encountered in drilling to 8,159 feet. Some little experience was required to find how short to make the 4½ inch drill stem, originally 45 feet long, in order to correspond with the lengthened stroke, but it finally turned out that reduction of the length to 25 feet was about right.

It was conclusively shown that with the hook-up described a more effective blow is delivered at the bottom of the hole by the tools, and consequently more hole is made in a given length of time than is the case where a long stem and a stiff socket are used with the shorter stroke.

For depths over 7,000 feet the improved plow-steel preformed wire drilling cable is preferred to cables wherein the wires have the ordinary "lay" or twist and this in spite of the increased first cost. Each wire is preformed to its ultimate position in the cable, reducing or eliminating the stretch that occurs with ordinary cables; the driller is enabled to keep the proper hitch on the line as easily at 7,000 feet or more as at 4,500 feet with unpreformed cables.

A major nuisance in the drilling of deep wells in the Appalachian area is the occurrence of small pockets of gas under high pressure that are found especially in the Devonian shale section above the Onondaga limestone. When tapped by the drill they often have force enough to throw the drill up the hole, kinking the line and presenting the driller with a fishing job. After much troublesome experience it was found that by keeping about 200 feet of a heavy salt brine in the hole, the explosion of the gas pocket could be so effectively damped that no damage to the tools or line occurs, and without needing to cement and re-drill through the cavities usually produced by the explosion. The brine column has to be renewed each 24 hours and the mud bailed out.

Oversize Joints Reduce Drilling Costs—Harry F. Simons, in OIL & GAS JOURNAL, Vol. 38 (1940), No. 46, p. 197.

One of the principal items which has added to the drilling costs in the Illinois basin development has been the excessive wear on tool joints and drill pipe, the average drill stem making only about one-half the footage it would make in other areas. Some strings of drill pipe have made as little as 30,000 ft. of hole before they were junked, while others have made as much as 90,000 ft. of hole before they were considered unsafe.

The wear on the tool joints and pipe has put a premium on keeping the drill stem straight and on drill-stem management, i.e., changing the position of the various joints in the string so all of them receive approximately the same amount of wear. The effort to reduce the costs of this item has also led to hard-surfacing applications of various sorts although none of them have been completely successful principally because of the costs involved. However, apparently the most successful method of increasing tool-joint life to date has been the introduction of oversize tool joints on drill pipe used by the Pure Oil Co. on its rigs.

The outside diameter of these oversize joints is 4⅞ inch, or ¼ inch thicker than the regular joint; this does not involve any change in derrick equipment. They have shown a 33 per cent increase in the amount of hole that could be drilled before replacement became necessary. So far, three strings of drill pipe have been equipped with the larger joints and each set has made 11 or 12 wells, or three wells more than the regular joints have been making, this amounts to approximately 9,000 ft. of hole. Premium for the oversize joints is 5 percent per ¼ inch added to the outside diameter.

A tool-joint examination at the conclusion of drilling approximately 11,500 ft. of hole with one string of pipe equipped with oversize joints showed that the average diameter of both the pins and boxes was 4.44/64 inch or ⅛ inch larger than the regular joint when new.

When the second set of oversize joints is worn and ready for replacement, a problem presents itself as the pipe has not sufficient life in it to warrant the installation of new joints and yet it still is capable of considerable more service. At 58,000 ft., the installation of new joints would call for a total footage of about 90,000 ft. and there have been very few strings of pipe to make that amount of hole in Illinois. An economical method of applying hard-surfacing material would help solve this problem and efforts are being made in this direction by a number of firms. Applications of hard-surfacing material to date have added five or six wells to the life of the drill pipe.

OPERATION

Paraffin Removal from Tubing in Flowing Wells—J. Daviss Collett, Jr. before AMERICAN PETROLEUM INSTITUTE, Division of Production, Houston, March, 1940; 11 pages.

This extensive and quite detailed study of paraffin removal is limited to flowing wells where the tubing is 2 and 2½ inch. The methods discussed can be applied to other sizes, but the statements of cost, which are given with much completeness, will be different.

The author reaches the following general conclusions:

For general application the use of heat has proved unsatisfactory for paraffin removal. Chemical treatment to remove paraffin is successful in some areas, but is not suitable for general application. The automatic knife or "go-devil" scraper can be used quite satisfactorily where well and flowing conditions are suitable. For extremely bad paraffin, the individual well unit is most satisfactory and inexpensive of operation. For general application, the mobile unit is most suitable and is the cheapest method of handling the problem. This is especially true if the wells are cut on a regular schedule. Light equipment with the reel and engine built as a unit is most satisfactory, and for speed in cutting the paraffin tools should be carefully designed.

Pressure Maintenance in Cunningham Lansing Lime Pool—Colin C. Rae, before AMERICAN PETROLEUM INSTITUTE, Division of Production, Wichita, March, 1940; 5 pages.

The author makes out a case for pressure maintenance. Many Cunningham-Lansing (Kansas) oil wells would now be unprofitable and ready for abandonment if the present project had not been inaugurated.

The past oil production of this field to date has been about 2,000,000 bbl. of which 1,009,000 bbl. were produced prior to pressure maintenance. At that time the normal ultimate oil production without pressure maintenance could be estimated at 2,800,000 bbl. Since the project has been started and has had time to prove itself an ultimate production of 5,200,000 bbl. is promised, a result which is offering considerable encouragement to other pressure maintenance projects in the Lansing-Kansas City formations.

The total volume of gas input has been 85 percent by volume of the gas produced. In spite of difficulties of consolidating the ownership of oil leases under one operator and in obtaining cooperation from all operators, the erection of a natural gasoline plant in this field has justified itself. It is regretable that the project was not completed until the average bottom hole pressure had declined from 1,100 to 424 lbs. It would have been much better to begin pressure maintenance early in the life of the pool when larger gas volumes are available. However, there are signs that the future will see closer cooperation between operators in this region.

Recent Developments in Plugging Off Bottom Hole Water in Arbuckle Lime—J. N. Miles, before AMERICAN PETROLEUM INSTITUTE, Division of Petroleum, Wichita, March, 1940.

The history of the production of oil from the Arbuckle lime in Kansas is that a well in this horizon eventually begins producing salt water in increasing amounts as production is continued; finally, the volume of salt water is so great that the well becomes unprofitable even while many barrels of oil remain in the horizon.

According to the author, the best time to think about remedial measure is when the salt water makes its first appearance. Salt water encroachment can be controlled by one of three ways;(a) shallow penetration of the hole into the producing horizon; (b) moderating the rate of withdrawal, and (c) remedial work such as water shut-offs.

A modification of existing methods under (c) has been developed for the Arbuckle lime which has the merit of involving a minimum of cost. The basic features of the method are the use of acid to increase the permeability and porosity of the lime in the water-producing zone; into the space thus opened up cement is slowly injected under low pressure.

Without this opening-up action of the acid—and the farther out the better—the shut-off job will be more or less ineffective. The ideal condition is where there are hard strata between pay zones and where the acid has penetrated deeply.

Experience indicates that the acid reaction will take place in the water zone in preference to the oil zone if given an equal opportunity, and by the same token cement will enter the water zone in preference to the oil zone. The necessary operations are clearly and fully described in the paper. The cost per job should not exceed $1,000 and if taken in time the pay out is rapid.

NATURAL GAS

Application of Well-Test Data to the Study of a Specific Gas-Production Problem—M. A. Schellhardt, E. J. Dewees and W. H. Barlow, in U. S. BUREAU OF MINES REPORT OF INVESTIGATIONS No. 3493, March, 1940; 22 pages.

In recent years development of instruments and equipment for determining subsurface pressures and temperatures in gas and oil wells has made it feasible to obtain information that was not available in the past on many gas-production problems. The material presented in this report illustrates particularly the value of subsurface-temperature data in the study of subsurface leakage from gas wells.

The case in point is that of a gas well in Texas drilled to the Woodbine horizon at a depth of 5,971 feet, where it found a gas sand about 21 feet thick. Opposite this sand was a 68 ft. section of a 5-inch liner (bottom perforated); inside the liner was a 2-inch pipe, also bottom-perforated, reaching to the top.

The initial wellhead-pressure remained at about 2,598 pounds from the date of completion to a date three years later; then for the space of a year the pressure declined to 1,635 pounds. During this whole time only a relatively small amount of gas had been withdrawn, certainly not enough to account for the large pressure drop. The case was somewhat mystifying, because another gas well a short distance away, which had been drilled at approximately the same time to what was supposed to be the same sand, and which also had produced no great amount of gas, did not show a significant decrease of reservoir pressure.

These circumstances raised a suspicion that gas was escaping from the sand in the annular space outside the liner and was finding its way to a porous stratum located somewhere among the overlying formations. The problem then was to verify the suspicion.

As a basis for verification, it was taken into consideration that the temperature of the earth's crust varies regularly with depth. Therefore gas in a reservoir a mile under the ground should be quite warm (it was actually around 165 deg. F). If this warm gas was escaping upward the temperature of the shut-in well at different levels should show to what level it was rising. A temperature survey of the well was accordingly made. This revealed that there was an appreciable flow upward to a permeable stratum between 2,000 and 2,500 ft. below the derrick floor datum. The 5-inch liner was thereupon pulled and replaced by another which was cemented and gun-perforated. Thereafter pressure loss became immaterial.

CHEMISTRY

Autooxidation and Gum Forming Tendencies of Certain Hydrocarbons—Bernard Berger and R. W. Post in OIL AND GAS JOURNAL, Vol. 38 (1940), No. 46, pp. 81-84; 86.

Investigators who have worked on the problem of gum formations have not attempted to isolate any of the hydrocarbons in gasoline, but they have attempted by various means, to show what types of hydrocarbons might be responsible for those undesirable products. Attempts have also been made to gain some knowledge of the structure of a gum by studying the gum obtained from gasoline. This is almost a hopeless task since gasoline contains many hydrocarbons of diverse structures. It is obvious, therefore, that any attempt to study the mechanism of gum formation as well as the structure of gum itself is almost futile unless a substance of known structure is used as the starting material.

In order to study the effect of structure on gum-forming tendencies, eight hydrocarbons were selected. Four of them, pinene, limonene, cylclohexene and tetralin, belong to the unsaturated cyclic series, whereas three of the others, diallyl, 2-methyl-butene-2 and diisobutylene, are unsaturated acyclic hydrocarbons. Isooctane, 2,2,4-trimethyl pentane, was the only saturated hydrocarbon studied. Thus, it is seen that quite a representative number of hydrocarbons of different structures was taken.

The experimental procedure consisted in mixing the oils with either benzoyl peroxide, an aldehyde or an acid in bottles which were then exposed to strong light for varying periods followed by analyses to see what had occurred.

All the oils formed some gum even in the pure state. The greatest amount was formed by the substituted cyclic hydrocarbons. Maximum gum was generally reached in four weeks, after which there was some tendency for gum to decrease. Benzoyl peroxide favored gum formation in all cases except with tetralin, thus indicating that oxygen is necessary.

Water Treatment for Prevention of Scale and Corrosion in Water Flooding—F. T. Redman and Robert F. Mackie; before AMERICAN PETROLEUM INSTITUTE, Division of Production, Houston, March, 1940.

Coagulation, filtration, softening with both chemicals and zeolite, chlorination, and in some cases recarbonation have frequently been applied to waters used for flooding in an attempt to make them completely stable before their injection into the oil bearing sands. Even with the best of treatment, after-precipitation of calcium carbonate often takes place in these water supplies and the possibility that this precipitation is occurring in long flooding lines or on the face of the oil sands in the injection well is a problem worth of consideration.

It has been found that the precipitation of calcium carbonate, calcium sulphate, and iron are eliminated by the use of a concentration of metaphosphate of 2 to 5 ppm. It has also been found that the maintenance of metaphosphate in an aggressive water will greatly decrease the amount of corrosion taking place in the system.

This effect has been noticed in water with a concentration of total dissolved solids as high as 40,000 ppm., saturated with oxygen, which would otherwise be very corrosive. Controlled laboratory tests on the effect of high concentrations of various ions on corrosion indicate that while these ions increase the amount of corrosion occurring, the metaphosphate continues to be effective and the corrosive action of these brines is greatly reduced.

PHYSICS

Critical Solution Temperatures and Aniline Points of Some Butane Hydrocarbons—Clifford G. Ludeman, before Petroleum Division, AMERICAN CHEMICAL SOCIETY, Cincinnati Meeting, April, 1940.

Aniline points and critical solution temperatures are useful physical constants of hydrocarbons for the correlation of data. A method is outlined which enables these constants to be obtained for volatile hydrocarbons. The aniline points of *n*-butane, isobutane, and isobutene were found to be 83.1°, 107.6° and 14.9° C., respectively, and the critical solution temperatures of these hydrocarbons were 84.1°, 109.0°, and 15.8° C., respectively. These values confirm the minima which are indicated by the literature for the several hydrocarbon series of which these various butane hydrocarbons are members.

Spiral Screen Packing for Highly Efficient Laboratory Fractionating Columns. H. S. Lecky and R. H. Ewell, before Petroleum Division, AMERICAN CHEMICAL SOCIETY, Cincinnati Meeting, April, 1940.

A new type of packing embodying a continuous flat spiral of metal gauze enclosed between two concentric tubes is described. This packing gives very high efficiencies, 32 plates per foot or 0.375″ H.E.T.P., exceeding the Stedman conical wire gauze packing. It is also characterized by large throughput without loss of efficiency, small hold-up and small pressure drop. The performance is compared with a number of common types of packing, including the Stedman packing.

Heat of Formation of Gaseous Hydrocarbons—Frederick D. Rossini, before Petroleum Division, AMERICAN CHEMICAL SOCIETY, Cincinnati Meeting, April, 1940.

The existing data leading to values of the heats of formation of hydrocarbons in the gaseous state are discussed. "Best" values are given for the heats of formation of 8 paraffin hydrocarbons (through the pentanes), 16 olefin hydrocarbons (through the pentenes), and 3 acetylene hydrocarbons, all in the gaseous state. Regularities and irregularities in the heats of formation, and their changes with structure are discussed. Forthcoming data on the hexanes are mentioned.

The Present Status of the Statistical Method of Calculating Thermodynamic Functions—E. Bright Wilson, Jr., before Petroleum Division, AMERICAN CHEMICAL SOCIETY, Cincinnati Meeting, April, 1940.

The basic formulas for the approximate calculation of thermodynamic quantities from molecular constants are summarized, including an

extensive table of the harmonic oscillator contributions. Theoretical developments of recent years are reviewed, especially those dealing with the problem of internal torsional motions. A discussion of the sources of the necessary molecular constants is given, and a list, with references, of the calculations which have been published is included.

Applications of the Mass Spectrometer to Problems in the Petroleum Industry.—Herbert Hoover, Jr., and Harold Washburn, in AMERICAN INSTITUTE MINING & METALLURGICAL ENGINEERS, Technical Publication No. 1205 (Petroleum Technology, May, 1940).

This is a preliminary report on a new instrument that offers the possibility of solving many problems which cannot easily be accomplished by other methods. It is called the mass spectrometer, which has very little or nothing in common with the more familiar optical or grading instruments.

The mass spectrometer has been used before for a number of purposes of purely scientific interest, but has now become of practical promise because it can be applied to the chemical analysis of unknown gas and vapor mixtures. It can not only operate on extremely small quantities such as the tenth of a cubic millimeter but can distinguish between and estimate ethane and methane, or between ethylene and ethane, or between n-butane and i-butane in the same mixture, even when the proportion of the one or the other is extremely small. The operation requires not more than five minutes.

The principle of the instrument is that a suitably constructed ionization chamber, kept a high vacuum, is placed in a uniform magnetic field and a small amount of the gas is leaked into the chamber. The ionized molecules are obliged by the magnet to follow a curved path, the radius of which is a function of their molecular weights, so molecules of different weights will follow different paths; being thus separated they can easily be identified by certain physical characteristics.

A spectrometer with several exit slits, each slit so placed that it passes only the ions of a single mass, has many practical advantages. With such a spectrometer the intensities of several ions having different masses can be simultaneously and continuously indicated and recorded. With such an instrument, a continuous record of certain constituents of a variable gas mixture can be obtained. This type of analysis is useful in refinery control. The output of such a spectrometer may be made to control automatically the process being monitored, according to the chemical composition of the output. Automatic control of recycling operations is only one of many possible applications.

Other possible applications are the quantitative analysis of hydrocarbons and other gases in soil samples ("geochemical prospecting for oil"), drilling mud samples and borehole cores. A routine technique has been developed for qualitative and quantitative determination of the paraffin series, including methane, ethane, propane, butane, pentane and still heavier members, including some of their isomers.

REFINING

Knocking Octanes. C. H. van Hartesveldt and H. W. Field, before AMERICAN PETROLEUM INSTITUTE, Fort Worth meeting, May 1940.

Octane numbers of gasolines have received much attention in recent years in the public press, with the result that "high test" and "high octane" have become synonymous expressions; and the role of high-octane gasoline as a "cure-all" for the ills of motor-car performance has been accepted more widely than the facts warrant.

In this paper a comparison is presented of the value of improved automobile performance as observed by the "average driver", with the incremental costs of producing gasolines of successively higher octane numbers. The automobile-performance observations were made in car models now being operated by the public, rather than in engines specifically designed for extremely high-octane gasolines.

Further, it is notable, in view of many recent controversies, that "road octanes" are used throughout the discussion, even though it is admitted that the road-octane method leaves something to be desired in the way of reproducibility from car to car.

The improvement in the performance of present-day motor cars, as a result of wide-range increases in gasoline octane numbers, is shown to be minor relative to the increase in refinery cost of effecting these octane increases as reflected in potential reduction of the profit returns on investments in the petroleum industry.

A note of caution is struck, lest the refiners let competitive enthusiasm undermine the financial stability of the industry instead of proceeding on a sane and logical course of developments for the future.

The basis of this note of caution is a conclusion drawn from a large amount of data which shows that it costs 5 cents a barrel extra to make fuel with octane number in the range 74 to 80, and that to get above the 74 octane base the refiners in 1939 went to an expense that absorbed almost 40 percent of the industry's earnings.

Practical Removal of Sulfuric-Acid Fog by Bubble-Phase Absorption—D. W. Bransky and F. F. Diwoky, before AMERICAN PETROLEUM INSTITUTE, Fort Worth Meeting, May, 1940.

Various methods of the removal of H_2SO_4 droplets from the stack gases of sulfuric-acid manufacturing and concentrating plants have been evaluated. The various known methods have been divided into two categories, viz., effective and ineffective, according to the practicability of the method from both the viewpoint of sulfuric-acid removal and the economic picture. Effective methods such as: 1, the filtration of the stack gases through various wetted media; 2, the decomposition of acid mist by heating to 1,000 deg F. or above under controlled conditions of combustion; 3, the use of Cottrell precipitators; 4, the use of steam ejectors with subsequent condensation of the steam; and, 5, the use of turbo-mixers were discarded because of high investment or high operating costs. A new method, in which the gas is bubbled through an aqueous solution of a foam-producing substance, has been found to be extremely effective in removing H_2SO_4 droplets, and has a very low investment cost.

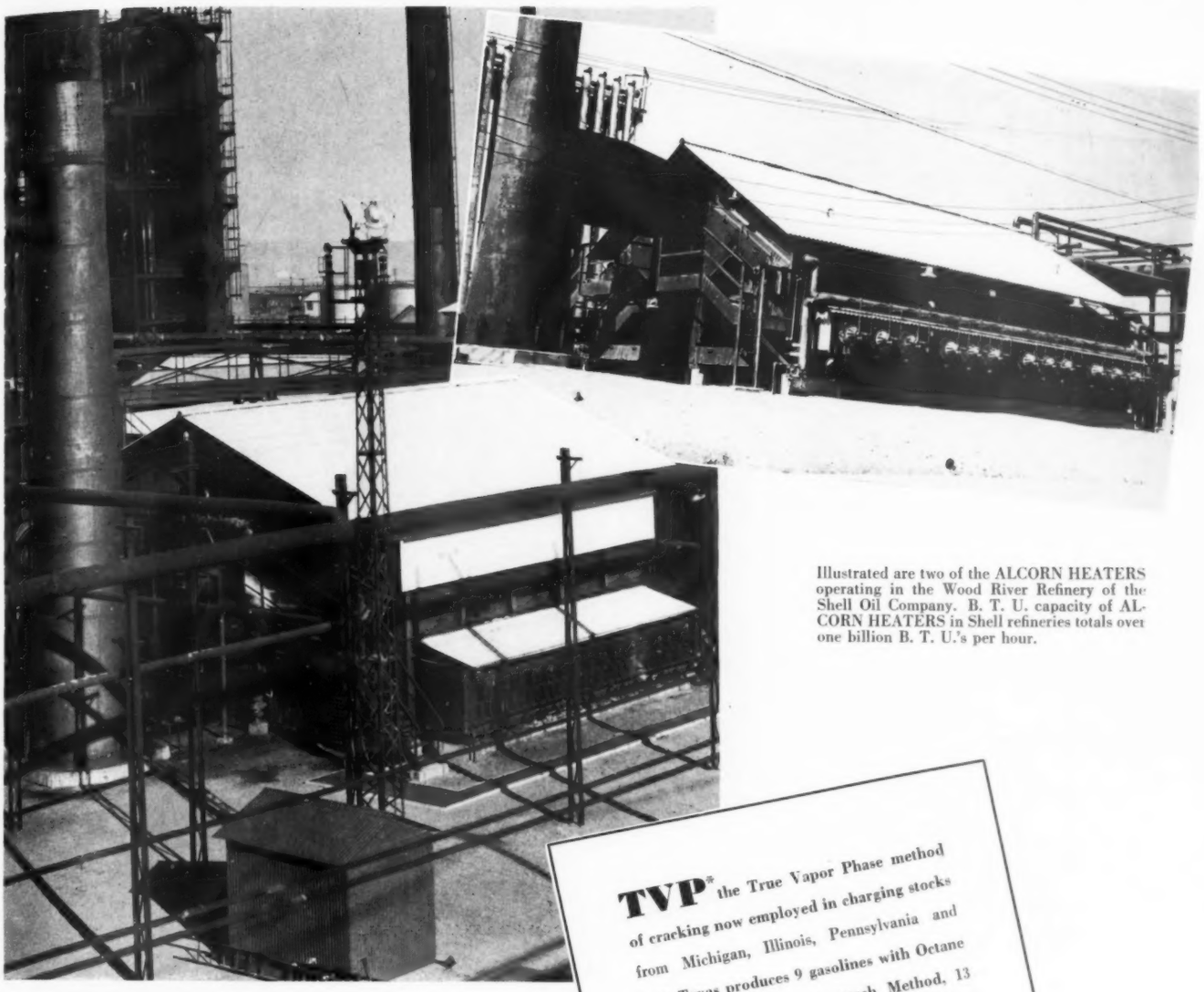
The most effective foam-forming agent found consists of the sulfonic acids obtained from the hydrolysis product of the acid sludge derived from the treatment of petroleum. These acids are readily soluble in water, form a relatively stable bubble phase in a dilute aqueous or sulfuric-acid solution, and are soluble in aqueous solutions of H_2SO_4 containing up to 10 per cent acidity. A laboratory investigation, subsequently followed by a pilot-plant investigation, indicated that the method was effective in removing approximately 90 to 98 percent of the H_2SO_4 in the incoming gas, and that the efficiency of the H_2SO_4 removal was practically independent of the concentration of the H_2SO_4 in the gas and the temperature of the solution over ranges of 80 to 180 deg. F. It was found also that the efficiency of removal was affected greatly by contact time. The pilot-plant experiments demonstrated that with a contact time of 10 sec. to 11 sec. approximately 93 to 95 percent of the total H_2SO_4 may be removed in continuous equipment having a pressure drop of approximately 2 in. of water. Economic calculations have indicated installation, operating, and repair cost to be approximately 50 percent that of equivalent electrical precipitation equipment.

Caustic Washing of Gasoline and Caustic Regeneration—L. M. Henderson, G. W. Ayers, Jr., and C. M. Ridgway in OIL & GAS JOURNAL, Vol. 38 (1940), No. 46, pp. 114-118, 121.

Caustic washing of gasoline is of practical interest and is extensively practiced because it removes certain-sulfur compounds that have bad odors and diminish the TEL susceptibility of the gasoline. The caustic solution may be regenerated for reuse by means of a simple steam stripping.

Some gasolines, however, contain compounds which react with caustic soda to form products which do not regenerate to form free caustic on steam stripping. Some crude oils and gasolines derived therefrom contain organic compounds that are much more acidic than aliphatic mercaptans. In recent work on cracked gasolines from Texas crudes, it was observed that acetic acid as well as many other organic acidic compounds were present having an acid strength approximating that of acetic acid. When caustic soda was used repeatedly on such gasolines the sodium salts of these acids accumulated in the caustic and limited the extent to which the caustic could be regenerated by steam stripping, inasmuch as the salts of the acids in question are not appreciably hydrolyzed in the boiling aqueous solution. Not all crudes or gasolines contain any significant quantities of such acidic bodies, although their prevalence may be more general than is realized. The acidity varies from crude to crude and from product to product, e.g. a Texas crude was examined which possessed an acidity equivalent to 261 lb. NaOH per 1,000 bbl. crude while an Arkansas crude had an acidity equivalent to only 13 lb. NaOH per 1,000 bbl.

An examination of spent caustic solutions that had been used repeatedly in a refinery on cracked Texas gasoline and repeatedly regenerated, showed that with successive regenerations an increasing fraction of the mercaptans was defying regeneration. It was shown in the laboratory that a specific portion of the mercaptans in the solution could not be removed even with excessively large quantities of steam. This indicated that these residual mercaptans were distinctly more acidic than the low-boiling aliphatic mercaptans. Therefore, certain spent caustic solutions which contained a mercaptan that resisted removal by steam stripping were subjected to steam at various temperatures, dilutions and amounts of steam with little change in the quantity of residual mercaptan. A chemical examination of the regenerated caustic which contained the residual mercaptan not removed by steam revealed the mercaptan to be almost wholly *o*-thiocresol with small amounts of *p*-thiocresol and thiophenol. *o*-Thiocresol is a fairly strong acid, almost as strong as acetic acid.



Illustrated are two of the ALCORN HEATERS operating in the Wood River Refinery of the Shell Oil Company. B. T. U. capacity of ALCORN HEATERS in Shell refineries totals over one billion B. T. U.'s per hour.

TVP* the True Vapor Phase method of cracking now employed in charging stocks from Michigan, Illinois, Pennsylvania and East Texas produces 9 gasolines with Octane Rating, by the 1939 Research Method, 13 numbers higher than when compared with A.S.T.M. Motor Method ratings. Road test values correlate closely the Research Octane numbers.

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Whichever came first, **ALCORN HEATERS** were preferred in the early stages of oil refining and are preferred now. There is an **ALCORN HEATER** for every method of refining, capacities from 2 to 100 million b.t.u.'s per hour and from 3 to 23 thousand barrels per day — for low temperature lube units, for topping, cracking (liquid or vapor phase) hydrogenation units, rerun units, alkylation units, natural gasoline units, absorption or recycling units, etc.

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Except for the fact that thiocresols consume caustic, it was observed that their presence in the caustic did not interfere with the ability of the caustic to remove mercaptans from gasoline, provided an adequate concentration of free or available caustic soda was maintained. To show that the thiocresols do not pass from the caustic solution to the gasoline, several gasolines containing no mercaptans were agitated with a regenerated caustic solution containing *o*-thiocresol. The gasolines did not extract the thiocresols from the caustic solutions. Obviously the regenerated solutions containing thiocresols or other mercaptans must not be allowed to become acid while in contact with the gasoline, for then the mercaptans will go into solution in the gasoline.

A New Heat Transfer Medium for High Temperatures—W. E. Kirst, J. B. Castner and W. M. Nagle, before AMERICAN INSTITUTE CHEMICAL ENGINEERS, Buffalo Meeting, May, 1940.

A new chemical mixture used as a heating and cooling liquid which will transfer heat of around 900 deg. F. is announced. The mixture, consisting of approximately 40 percent sodium nitrite, 7 percent sodium nitrate and 53 percent potassium nitrate by weight, has a low melting point, high heat transfer rate, and a thermal stability and a lack of corrosive action on steel at temperatures above those obtainable with Dowtherm, hot oil or high steam pressure.

Other chemicals and oils ordinarily used for heat transfer at high temperatures are unsuitable at temperatures over 600 deg. F. because the cooling materials themselves break down.

In single units in the oil industry over 1,000,000 pounds of the salt mixture are being pumped through the system at temperatures around 800 deg. F. While these large quantities of salt have been used up to now only in oil refinery plants, the economical use of this mixture at such high temperatures demonstrates it will be practical for numerous heating installations.

In the past engineers had to use very high pressure equipment to transmit heat at these high temperatures, but, with the salt, simple steel construction for atmospheric pressure is satisfactory. The salt is termed "HTS" an abbreviation for heat transfer salt.

Under representative conditions, the properties of the salt are as follows: specific heat 0.373; specific gravity range at these temperatures 1.8 to 2.0; viscosity 1 to 10 centipoises; individual heat transfer coefficient, 858. The solid salt may be melted with 150 pounds steam pressure at 288 deg. F., and when molten can be pumped like water.

It requires 48 air pipes to transfer the same amount of heat as one pipe handling "HTS" will transmit. Theoretically it would require 1,700 times as much power to force the air through these pipes as would be required to pump the salt solution.

Mixture of Ketones Used to Dewax Motor Lubricants. A. J. Mueller, in OIL AND GAS JOURNAL, Vol. 38 (1940), No. 39, pp. 54; 56.

Brief details are given of operations in a 2,000 bbl. solvent dewaxing plant working on Illinois (Louden) waxy distillate. The solvent used is a mixture of methyl n-propyl ketone and methyl n-butyl ketone, each of which singly has certain disadvantages but when mixed constitute a dewaxing solvent that has a high filtering rate and does not require a precoat on the filter cloth. Throughputs as high as 40 percent above designed capacity have been obtained. There is a wide spread, as much as 16 deg. F., between the dewaxing temperature and the pour point of the dewaxed oil. Solvent losses average 0.1 percent.

Causes, Prevention and Control of Fires on Light Liquid Hydrocarbons—H. A. Heiss, in OIL & GAS JOURNAL, Vol. 38 (1940), No. 46, pp. 135, 138, 140, 142.

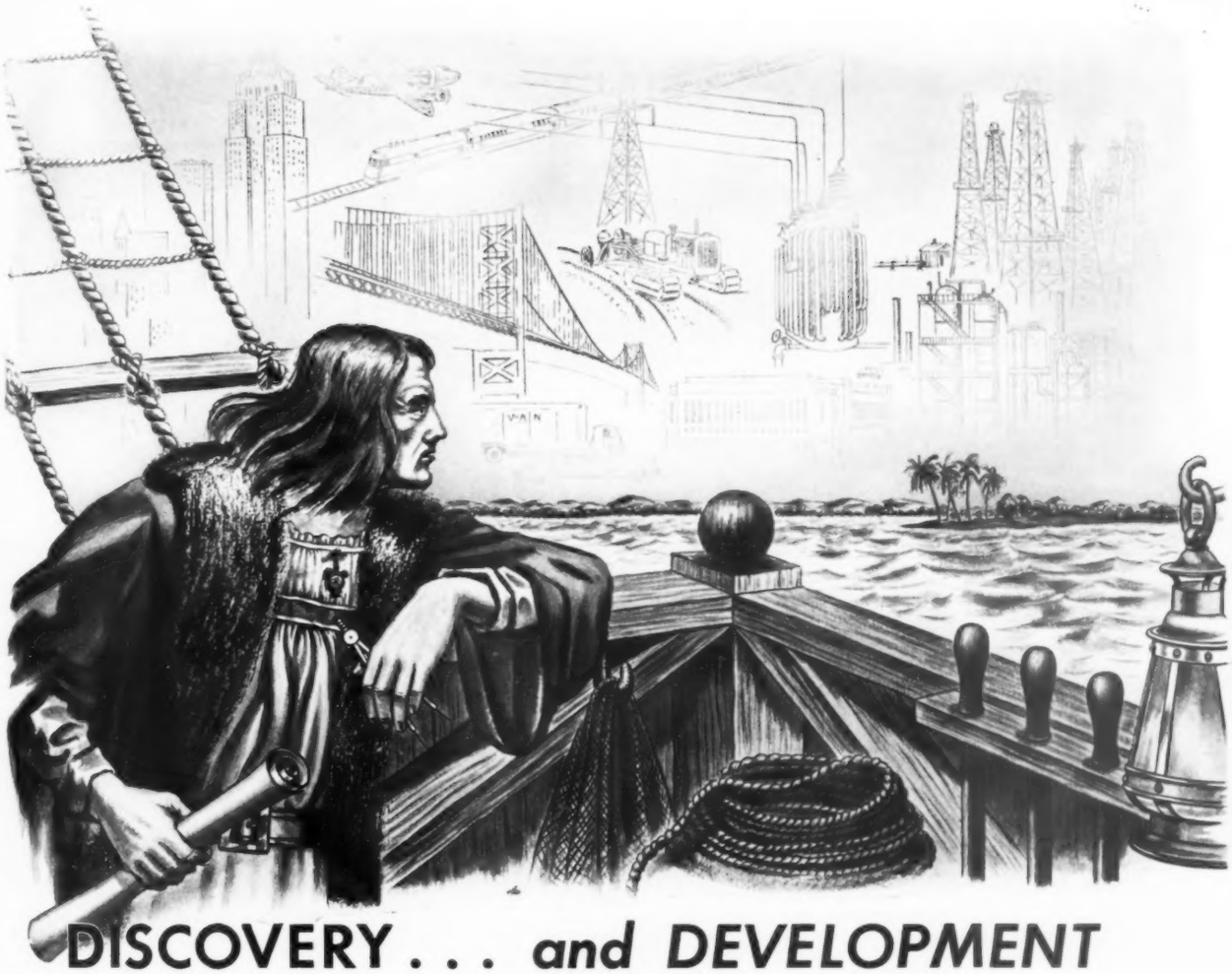
During recent years it has become increasingly imperative to recover light petroleum products to provide feed stock for such recent processes as polymerization, alkylation, etc. Thus it has become necessary to recover and handle not only butane as liquid but also, in many cases, propane and even lighter hydrocarbons. The handling of such stocks as liquids usually requires the use of high pressures which has increased fire hazards. This is reflected by the increasing number of fires which are occurring on such liquids. A study of recent fires has shown, however, that many could have been prevented had the individuals involved been more familiar with not only the fundamental nature of fire and fire hazards but also with certain physical properties of light liquid hydrocarbons. It was also revealed that the loss from such fires could have been reduced had the limitations of the several methods of fighting such fires been more thoroughly understood and if certain measures for fire protection had been employed.

Aside from an educational program designed to acquaint refinery employees with the nature of the problem, the Standard Oil Co. (Ind.) has carried out an experimental investigation on the best means of extinguishing fires that involve these light products. From this investigation several general conclusions are drawn:

Although this experimental work was carried out on equipment too small to permit the direct application of the results to storage conditions (with the exception of the tests on water fog) several general conclusions were drawn, namely:

1. Fires on open tanks containing light liquid hydrocarbons can probably be extinguished with reasonable quantities of foam applied at reasonable rates provided the Reid vapor pressure of the stock burning was not higher than 36 to 38 lb.

2. Steam would not be effective in extinguishing an open-tank fire.



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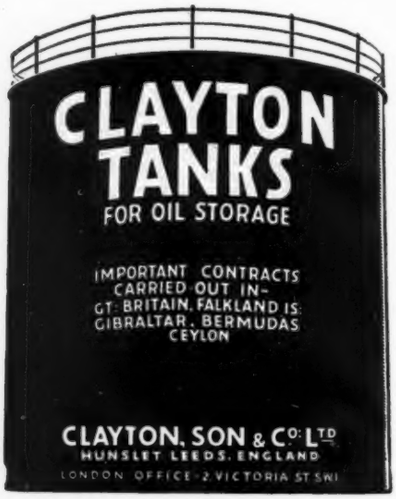

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3. Although carbon dioxide might be effective on an open-tank fire the amount required would be too great to be practicable.

4. Fire foam applied in limited quantities to the liquid surface would not extinguish a fire burning at a vent or at a rupture of the tank roof.

5. Carbon dioxide applied, with fire foam, to the vapor space of a tank would extinguish a fire burning at a vent but the amount required would be so great as to render its use impracticable.

6. Steam, carbon dioxide, or water fog applied to the base of flames burning at a vent would be effective extinguishers.

Considering the above conclusions, it appeared that while open-tank fires and vent fires may be extinguished, no practicable method of dealing with fires which might occur at a rupture in a roof was found. On the other hand, with a properly designed tankage system the problem of fire protection should be reduced to means for extinguishing vent fires.

ASPHALT AND TAR

Flow Properties of Bituminous Materials—A. R. Lee, J. B. Warren and D. B. Waters, in JOURNAL INSTITUTE PETROLEUM, Vol. 26 (1940), No. 197, pp. 101-128.

An investigation has been started at the British Road Research Laboratory to correlate the behaviour on the road of bituminous surfacings with therheological characteristics of their binders and of mixtures prepared in the laboratory. This investigation thus involves initially an attempt to evaluate in absolute units the viscous and elastic properties of both the bituminous binders and the consolidated bitumen-aggregate mixtures.

The results so far obtained indicate that the flow properties of a bitumen-aggregate mixture are determined by the nature and grading of the aggregate, and by the quantity, the viscosity and the nature of the binder. The more plastic the binder, the greater is the value of the plastic flow index of the mixture. The logarithmic temperature coefficient of flow of the mixture (defined as $\triangle$ log. r/ $\triangle$ log. T) is equal to that of the binder. The fact that, for a given change in temperature, the relative change in rate of flow of the mixture is the same as that produced in the viscosity of the binder indicates that the rate of flow of the mixture is inversely proportional to the viscosity of the binder in the mixture. The existence of this relation makes it possible to follow the change in viscosity of the binder in a bituminous road-surfacing material by means of mechanical tests.

Research in Soil Stabilization with Emulsified Asphalt—C. L. McKesson, in PROCEEDINGS AMERICAN SOCIETY TESTING MATERIALS, Vol. 39, pp. 1123-1139.

The use of emulsified asphalt for soil stabilization in engineering work (road building) is now general enough to require a test procedure for determining the suitability of commercial asphalt emulsions for the purpose. After an evolutionary period the test now favored consists in mixing samples of the dry soil with enough asphalt emulsion to allow cylindrical plugs to be formed. These plugs are up-ended on a wet cotton flannel blotter in a closed box where they remain seven days, when the amount of water absorbed by capillary attraction is determined. The stabilized sample should not absorb more than 12 percent of the moisture absorbed by the unstabilized soil.

These tests show that fine particle size in an emulsion is an important property for effective stabilization. One emulsion had an average particle size of 47 μ, the other 2.9 μ. Ten percent of the coarse emulsion is shown to be less effective than 4 percent of the finely dispersed emulsion.

By the use of these test methods, the consistency of the bitumen used was found to be an important factor in the efficiency of stabilization.

The tests proved sensitive enough to differentiate between two emulsions in which the only difference was in the penetration of the asphalt used in the emulsion. Asphalt of 58 penetration at 77 deg. F. is shown to be about 10 percent more effective than an asphalt of 209 penetration.

Evaluating the Adhesive Properties of Asphalt—August Holmes, in PROCEEDINGS AMERICAN SOCIETY TESTING MATERIALS, Vol. 39, pp. 1140-1152.

In order to evaluate the "adhesivity" of an asphalt, that is, its resistance to being displaced from the aggregate surface in the presence of water, laboratory tests of various types have been employed. These can be grouped as partition, stripping resistance, water-displacement, briquet-soaking and abrasion-displacement tests. Of these various types, the water-displacement test appears to give the most indicative results. The use of the circular track affords a more practical means for evaluating adhesivity and details of its construction and operation have been described. According to the results obtained by the circular track, asphalt adhesivity can be increased by the use of wetting agents and the life of a paving mixture has thereby been increased up to 3.8 times that constructed with untreated asphalt.

Improved adhesivity can be obtained by the addition of an activating agent or adhesivity promoter to the asphalt. For this purpose, fatty acids, fats, complex organic compounds, and heavy metal soaps have been proposed. The present information indicates that the best results are probably obtained by the heavy metal soaps such as the aluminum, iron, and lead soaps and certain high molecular weight organic compounds whose selection is generally a matter of trial and error.

When using heavy metals, the most economical procedure results from their incorporation entirely in the asphalt as heavy metal soaps. For certain refractory aggregates, however, in a wet condition, it has been found that pre-treatment of the aggregate and the incorporation of a heavy metal soap into the asphalt is the best means for obtaining a coating having permanent adhesivity.

USE

Phenolic Compounds from Petroleum Sources—Edward Field, Fred H. Dempster and George H. Tilson, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 32 (1940), No. 4, pp. 489-496.

Phenolic compounds of various types occur in petroleum fractions and in crude oil itself. These phenolic substances include phenol, the xylenols and cresols (cresylic acids), of which the latter seem to be the most important.

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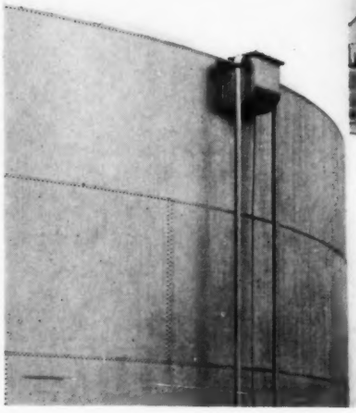

Views showing National FOMON Equipment and Chemicals in Fire House, and NATIONAL FOMON Type "L" Chamber with Moeller Tube welded to tank.

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traction of the phenolic bodies from cracked petroleum naphtha made by commercial cracking operations. The extraction is made by scrubbing with sodium hydroxide solution, which is incidental to the refining of the naphtha for the purpose of correcting color and also of mitigating noxious refinery odors. The caustic solution of phenols is then acidified with mineral acid; separated phenolic bodies rise to the top, and are removed and purified. The resulting products are clear, of good color, and of the highest quality in every respect.

Cresylic acids from petroleum are receiving wide recognition as germicides, fungicides, and disinfectants, and are the equal of coal tar acids from the standpoint of quality. The high phenol coefficient of F and G grades is particularly attractive to manufacturers of these types of products, whether they are used straight or in an emulsion with water and oil classed by the Bureau of Animal Industry as saponified cresol solution. The acids are brought into direct contact with the bacteria, which are immediately killed. They are applied in various dilutions for disinfecting chicken houses, stables, warehouses, etc., and to kill lice and vermin. Ticks, lice, and scab on sheep are killed by application of sheep dip compounds. Larger animals are sprayed periodically. They are finding increasing use in the form of dormant spray emulsions to control tree pests before any foliage appears. Another trade outlet for these acids is as flotation agents in the mining industry. The crushed ore is air-agitated with a mixture of water, oil, and cresylic acids; this agitation produces a froth which carries the fine sulfide particles to the surface and leaves the gangue to settle to the bottom. The action of the froth or fine bubbles in carrying the sulfide to the surface is based on surface tension, cresylic acids having been found very effective in reducing surface tension, which promotes good bubble formation. Cresylic acids from petroleum are selective in their action on metallic sulfides. These phenolic compounds also inhibit the formation of gum in cracked gasolines, for when they are removed by caustic washing of the oil, the latter becomes more and more susceptible to oxidation.

Diesel Traction, Using Methane—Anon. REVISTA ITALIANA PETROLIO, April, 1940, pp. 15, 17, 19.

Reference is made to some official Italian tests with modified Diesel engines using methane as fuel. The modifications consisted mainly in varying the compression ration and the installation of spark plugs. Thus equipped and mounted on a 50-passenger autobus and with eight 60-liter bombs containing methane under 200 atmospheres pressures, the engine developed 132.2 horse power at 1600 r.p.m. and drove the bus over a course of 320 miles without refueling. The preferred compression ratio is 1:9.

SUBSTITUTES

Industrial Synthesis of Hydrocarbons from Hydrogen and Carbon-Monoxide. A. J. V. Underwood, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 32 (1940), No. 4, pp. 449-454.

This is an account of some technical aspects of the Fischer-Tropsch synthesis in which a mixture of CO and H is catalyzed to produce liquid hydrocarbons. The amount of Fischer oil now being produced in Germany is about 1,000,000 tons a year. Similar plants have been built in France, Japan and Manchukuo. Cobalt, nickel and iron may be used as catalysts with or without promoters. In the present commercial installations cobalt and a promoter, supported on Kieselguhr, is found to give the largest yield and to have the longest life. Yields of 130 to 140 grams from one cubic meter have been obtained in one-stage operation (208 grams is theoretical); larger yields are had from lower velocities or multistage operation. The maximum yields are given at pressures from 1 to 15 atmospheres, but at these pressures less gasoline is formed. The controlling factor in output is not the time of contact with the catalyzer, but the rate of removal of the products of the catalytic reaction.

There is a variety of processes for the production of synthesis gas from coal or coke, which are the raw materials utilized in all the plants in Germany and France. Among the processes which can be used are the following:

Gasification of high-temperature or low-temperature coke in water gas generators, which may be accompanied by cracking of coke oven gas in the generators.

Direct gasification of noncaking coals with the Bubiag-Didier system.

Gasification of noncaking bituminous coals in water gas generators.

Production of synthesis gas from brown coal briquets in a Koppers generator.

Winkler generator, using brown coal coke.

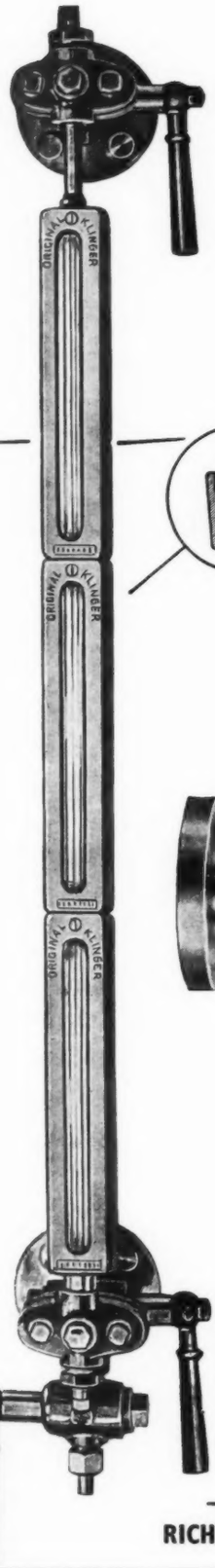
Lurgi process for gasification of noncaking bituminous coal, brown coal, or coke under pressure with the use of oxygen.

Gasification of noncaking coal by the Winter-shal-Schmalfeldt process.

When coal or coke is used for synthesis gas production, there is a deficiency of hydrogen. Carbon is discarded as carbon dioxide in order to adjust the ratio of hydrogen to carbon monoxide.

In the United States at present the most interesting raw material for the process is methane. Large quantities are available and in some cases have substantially no value. It is less difficult to produce synthesis gas from methane than from solid fuels, and a smaller investment is required for equipment.

Operating requirements are absence of sulfur



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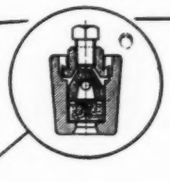

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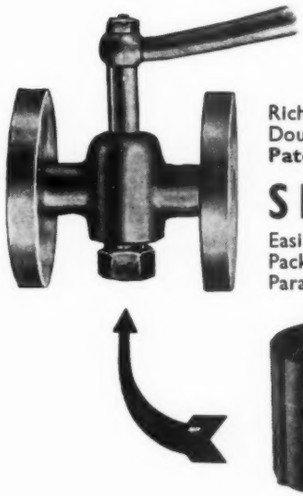

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from the synthesis gas and extremely accurate control of the temperature, which makes necessary removing the heat of reaction by cooling.

The products are straight-chain hydrocarbons. The gasoline fraction is therefore of low octane number and the Diesel oil fraction of high cetane number. The paraffin wax fraction can be converted into waxes of various melting points. A wax melting at 195 deg. F. (90.6 deg. C.) is being produced commercially on a large scale. Waxes with even higher melting points can be made for special purposes. Synthetic paraffin wax is being used in Germany to obtain synthetic fatty acids by oxidation.

Part of the Fischer product can be utilized for the production of synthetic lubricating oil. There are two ways in which this can be done. Suitable paraffin hydrocarbons can be chlorinated and these compounds coupled with aromatic hydrocarbons. The other method involves the polymerization of heavy olefins by the use of aluminum chloride. The lubricating oils by polymerization are of high quality and are being produced commercially in Germany. When these oils are subjected to an oxidation test, they show a smaller formation of carbon but a larger increase in viscosity than lubricating oils from natural sources. The resistance to oxygen can be improved by mild hydrogenation.

BOOKS

Proceedings American Society for Testing Materials, 42nd Annual Meeting, 1939; 1341 pages; published 1940 by the Society, Philadelphia. $8.50 paper; $9 cloth.

The ASTM has adopted a new scheme for its proceedings. All new tentative standards are now collected in a Book of Standards, and the Proceedings, formerly published as Committee Reports and Technical Papers separately, are now issued in one big volume.

The usual broad field is covered. The section devoted to petroleum products relates mostly to gasoline analysis, proposed specifications for aviation gasoline, gaseous fuels and road materials.

The True Facts About the Expropriation of the Oil Companies' Properties in Mexico. Published 1940 by GOVERNMENT OF MEXICO. Mexico City, 271 pages.

This paper bound book, which bears the name

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of no author but is accompanied by a neatly printed card "With the compliments of the Government of Mexico" is stated to be an answer of that government to the "slanderous statements" circulated by the oil companies whose Mexican properties have been seized for the good of the Mexican nation in the due and proper exercise of Mexican sovereignty.

The "true facts", as seen from the Mexican angle, are that the companies refused to obey the decision of the Mexican Labor Board in certain matters affecting their employees, even after the Supreme Court of Mexico had upheld the Labor Board in its constitutional right to render and enforce the decisions complained of. The refusal of the companies to enter into a contract with their workers along lines laid down by the Labor Board amounted to suspension of operation of the fields, which threatened the country with a serious shortage of indispensable fuel.

To avert an impending national calamity the Government stepped in to seize and operate the properties, of which it assumed ownership with the full intention of giving the owners full compensation. The author of the book is extremely careful to point out the essential difference between "confiscation" and "expropriation"; confiscation is defined as seizure with no intention to pay, while expropriation is seizure with intention to pay. It is claimed that Mexico has every intention to pay, and is only waiting for the companies to agree to arbitration on the amount due them. Arbitration before an international tribunal which would consider whether the properties shall be returned to their former owners is firmly ruled out, because the right of a sovereign nation to take and hold private property for public purposes is a universally recognized principle.

A person unfamiliar with the full history of this case would say that the writer, whoever he is, has made a masterly legalistic presentation of his case. But the "true facts" which he presents do not include all the true facts. In drawing a distinction between confiscation and expropriation not the faintest reference is made to the confiscatory nature of the orders addressed to the companies by the Labor Board, which would have forced them to pay to the workers more than they were getting out of the properties; to make up the difference they would have to dip into their capital. To avoid this sort of confiscation they stopped operation.

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GENERAL

Workers in the Roumanian Petroleum Industry—Mihial Pizanty in MONITEUR PETROLE ROUMAIN, Vo'. 40 (1939), No. 20; 8 pages.

The accompanying table gives the first complete census of persons actually employed, in one capacity or another, in the Roumanian petroleum industry.

	Number of Workers
The Oil Fields	15,700
The Refineries	7,900
Central Services—	
Technical	110
Administrative—	
Higher Officials	310
Middle and Lower	1,878
Other Administrative	660
Outside Services—	
Technical	1,099
Administrative—	
Higher Officials	157
Middle and Lower	901
Other Administrative	3,105
Grand Total	31,900

One company (Astra Romana) employs a fifth of the total, and all but 2.7 percent work for the

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19 largest companies. The index of employment in the oil fields does not decrease proportionally to decrease in production of crude oil. Thus, between 1936 and 1938 production fell 34 percent, but oil-field employment only seven percent. In the same period refinery throughput decreased 28 percent and refinery employment five percent.

Note—The annual production (1939) of crude oil in Roumania being of the order of 46,000,000 bbl., the average annual production per worker (all categories) is of the order of 1,500 bbl.—Ed.

Metallurgical Coke from Petroleum Coke H. Hendler in MONITEUR PETROLE ROUMAIN, Vol. 41 (1940), No. 8, pp. 445-446.

Owing to import difficulties arising from the European war the Roumanian steel foundries have had great difficulty in obtaining natural coke from the dry distillation of bituminous coal. This brought up the question of using petroleum coke from cracking stills; but this material, although of great purity and large calorific value, has the serious fault of being too soft to stand up in the blast furnace. It is necessary therefore to treat the petroleum coke so that it will have the necessary hardness. This is done by pulverizing it, incorporating an inorganic binder such as natural clays or inorganic silicates. The mixture is briquetted and calcined in a regenerative furnace heated by the combustible gases (volatiles) that are driven off by the calcination. The incorporated mineral matter constitutes a sort of skeleton which gives the necessary rigidity.

In comparison with natural coke the metallurgical petroleum coke thus obtained has the following advantages:

(a) There is a smaller amount of slag and (b) the quantity of sulfur in the combustion gas is smaller.

Buna Rubbers. Albert Koch, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 32 (1940), No. 4, pp. 464-467.

In the coming years the world is likely to be supplied largely if not exclusively with synthetic substances having the same or better characteristics than natural rubber. The raw material for these synthetic rubbers may come from various sources, among which petroleum products or their derivatives will figure importantly. Among these is butadiene, of which the Germans are now making large use. (The name Buna is compounded from *bu*, taken from butadiene and *na*, taken from natrium (sodium) which is an active chemical used in the process).

The most interesting is the product known as Buna S, a mixed polymer of butadiene and styrene. It is produced in large quantities in Germany at present, principally for use in tires and mechanical rubber goods. Buna S represents such an improvement over natural rubber in heat resistance and abrasion resistance that it is by no means to be considered a mere substitute for natural rubber. Road tests with Buna S tires have demonstrated beyond doubt their superior wearing qualities as compared to natural rubber tires. For many technical purposes the superior heat resistance of Buna S is a valuable factor.

The swelling characteristics of Buna S vulcanizates in contact with gasoline and mineral oil are only a little better than those of natural rubber.

To the electrical cable industry Buna S is of real interest. The excellent heat resistance and superior aging properties of Buna S assures that cables covered with it will last much longer in service, particularly at high operating temperatures. The water absorption of Buna S is only about 65 per cent of that of natural rubber: this smaller figure corresponds closely to the water absorption of deproteinized natural rubber.

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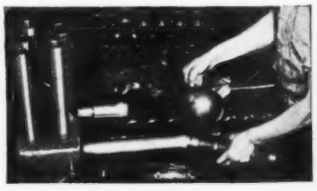

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